THE
POPULAR SCIENCE
MONTHLY

APRIL, 1911

# THE GENESIS OF THE LAW OF GRAVITY

By Professor JOHN C. SHEDD

OLIVET COLLEGE, OLIVET, MICH.

SINCE the earliest ages man has been interested in the world outside of himself. Thunderstorms, waterfalls, winds, waves, fire, the starry heavens have aroused his wonder, admiration or fear.

During the earlier stages of racial development the simplest phenomenon was explained by reference to some arbitrary power, and soon gods and demigods were conceived of as presiding over the agencies of nature. Later men who had wrested some of her secrets from nature or had won some victory over her were exalted to the position of heroes and worshipped, while their exploits, greatly magnified, became part of the legendary history of the race. Slowly man began to realize that there is a constancy about nature that may be expressed in general statements. These statements were often vaguely expressed as, "Nature abhors a vacuum," "Water and fire are antagonistic," "There are three elements, earth, air and water" or "earth, fire and water." These crude beginnings led to more careful and more systematic study of nature, and to more exact statements of what we now call the laws of nature.

It took long ages—perhaps we have not even yet reached the goal—for man to realize that the content of his study is here objective, so that the method of study must be *inductive* and not *deductive*. This being the case, the conclusions arrived at must be allowed to shape themselves regardless of consequences to antecedent beliefs. Thus it happened that the study of nature has been for ages hampered by many a prejudice and by many a "Thou shalt not" from churchman and philosopher.

Another and perhaps greater impediment than the inertia of the human mind was the ravage wrought by war and time. Could each

age have the full benefit of all preceding ages, could man in very truth be "the heir of all the ages," there would be no lost arts and the world would not have to learn over and over again lessons once mastered.

A last impediment may be mentioned, peculiar perhaps to problems like the discovery of the law under discussion. It is hard for a worker in any field not to attempt to reach forward to the final solution of his problem. This is true even if the data for generalization be most meager. Thus it has happened time after time that ill-formed theories have been advanced even by great minds. Indeed the very greatness of the man whose name the theory bears proves an added obstacle. Thus the dicta of Aristotle held sway for centuries and even Galileo's brilliant experiments at the leaning tower of Pisa could scarce overcome the false Aristotelian theory of falling bodies. Another example is Newton's theory of light which survived at least a hundred years, simply because it was Newton's.

We shall in the present paper seek to trace the history of the problem which found its final answer in Newton's *Law of Universal Gravitation.* This law may be stated in the following familiar terms: *"Every particle of matter attracts every other particle of matter with a force proportional to the mass of each and to the inverse square of the distance between them."*

In tracing the history of how the race came into a clear knowledge of this law we find two streams with their headwaters far back in history, slowly gathering volume age by age and finally uniting and bearing the world on to the long-sought-for goal. The first of these streams may be called *the study of pure motion,* or of *kinematics,* the second *the study of the causes of motion,* or of *dynamics.* The first is best illustrated by the history of astronomy as developed down to the seventeenth century, while the second is best illustrated by the history of mechanics during the same period.

In astronomy we shall pay attention only to those persons whose work has a bearing upon the present problem. The first name of worth seems to be that of Thales of Miletus (640–546 B.C.). With remarkable clearness he maintained the sphericity of the earth, the present theory of lunar eclipses, and the correct view regarding the source of the light received from the earth's satellite. He also suggested that the stars may be regarded as being of the same material as the earth. Thales was followed by his disciple, Anaximander (611–547), who was the first of the ancients to view the heavens with the eye of a philosopher. His name should be immortal, for it was he who first suggested that the earth moves about the sun as a center, a doctrine which became one of the tenets of the Ionian school.

Perhaps rapid progress might have been made in the explanation by natural causes of the phenomena of the heavens, but soon the jealous

PYTAGORAS
Philosophiam primus hoc est Sapientiam studiosam appellavit
Ex nummo æreo in Thesauro Christinæ Reginæ Aug

ire of the Athenians was aroused in behalf of their gods. As a result, history would have claimed the first martyr to scientific truth in the person of Anaxagoras (500–428), had not the great Pericles interposed in his behalf. Even so, the death penalty was but exchanged for that of banishment.

Another disciple of Thales was the illustrious Pythagoras (572–400), who not only held the views of his master, but, from observations on the altitude of the stars, measured in different places, demonstrated that the earth was round, or, at least, not flat. He conceived Venus to be both the morning and evening star—a view lost sight of, later, as shown by the double name, Lucifer and Hesperus, long applied to this planet. Most remarkable, perhaps, was his doctrine of the diurnal rotation of the earth and its annual motion about the sun. Less substantial, but longer-lived, was his fanciful notion of the harmony of

PTOLEMY.

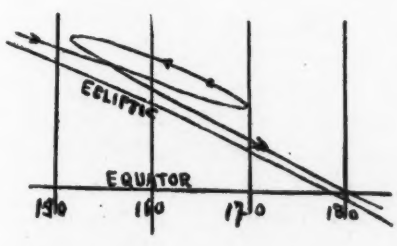
the spheres. He conceived each planet as held in place by being fixed in a celestial crystalline sphere which, in its rotation about the sun as center, carried the planet with it. Having observed that the planets move at different rates, it followed that the various spheres had different rates of rotation, and Pythagoras believed that some law controlled their motions. This he expressed by supposing that each sphere emitted sounds or notes like the strings of a harp, and the harmony was expressed by the belief that the several notes united in a beautiful celestial harmony of most exquisite music. More fantastic than suggestive, yet here in the far-away dawn of scientific history is the foreshadowing of the great thought which two millenniums later was given in Newton's universal law of gravitation.

The fate of Anaxagoras warned Pythagoras against being too overt

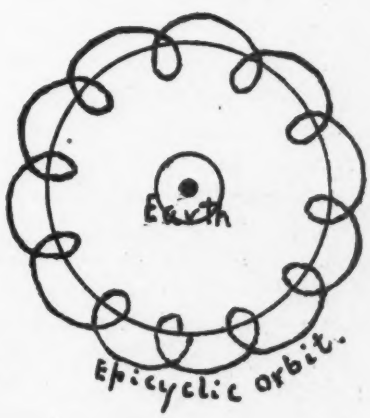
PTOLEMAIC SYSTEM.

in his public teaching, so that much that he taught was under the seal of secrecy. He also sought greater freedom by removing from Samos to Italy.

It might be expected that with so much to build upon the genius of Aristotle (384–322) would have accomplished great things in astronomical science. But not so! For some reason he rejected the theories of Pythagoras and, although he is said to have come into possession of great stores of Chaldean observations, on the capture of Babylon by Alexander the Great, he made no use of them. Perhaps the task of




APPARENT PATH OF MARS.



mastering these treasures was too great, perhaps his studies in anatomy and metaphysics prevented, but be that as it may, it must be acknowledged that his few pronouncements on physical science were for the most part erroneous and proved hindrances and not helps to those who followed him.

With the founding of the schools of Alexandria in the palmy days of the Ptolemys astronomy became a science. It was during this period that simultaneous measurements were made upon the altitude of the sun at Alexandria and Syene. At the latter place the sun at the summer solstice was on the zenith and at the former place 7° 12′ therefrom. From this and the known distance between stations the circumference of the earth was calculated as 250,000 stadia or 28,000 miles. This measurement was first made by Eratosthenes (276–196) and places him in the first rank in the Hall of Fame.

The centuries immediately preceding and following the beginning of the Christian era mark the rise both of astronomy and of geometry. It was probably due to progress in the latter science that Hipparchus (190–120 B.C.) and, later, Ptolemy (A.D. 120–170), were led to propound the system that still bears their names. This was a far more ambitious system than any that had preceded it, and sought, for the first time perhaps, to describe the exact path of the heavenly bodies. From our vantage point of wider knowledge it is easy to see its absurdities. Hasty judgment, however, must not be passed either upon its founders or upon the system itself.

In the first place, it was based upon observations; in other words, it was a generalization from data.

Secondly, it satisfactorily explained the observations contained in the premises.

Thirdly, it made possible the forecasting of eclipses.

The characteristics of the system may be given as follows:

1. The earth is a globe set immovable at the center of the celestial sphere—which sphere carries the fixed stars and revolves once per day.

2. The size of the earth is insignificant in comparison with that of the celestial sphere.

3. Seven planets revolve around the earth in the following order—the moon, Mercury, Venus, the Sun, Mars, Jupiter, Saturn.

4. The moon and sun move in excentric circles, the rest in epicycles.

Of the several considerations that must have induced the Alexandrian school to adopt this system we may note:

I. The Pythagorean system called for a moving earth, the Ptolemaic did not.

II. The observed motions of the planets were explained by the Ptolemaic system, and, while it is true that the Pythagorean system was capable of this also, it does not appear that the test by actual calculation had been made.

III. The system seemed adequate, was geocentric and appealed to the popular imagination.

Some of the more obvious criticisms of the system may be mentioned:

I. The ancients believed the sun to be larger than the earth—it would be more likely to be the center of the system.

II. The diurnal motion of the earth offered a simple explanation of the apparent motion of the heavens—the simple should prevail when opposed to the complex.

III. The Pythagorean system gave the same law of motion (the circle) to all the members of the system, while in the Ptolemaic system the moon and sun moved in circles and the rest in epicycles.

The cumbersome Ptolemaic system, having been adopted, became with the passage of time deeply rooted in the philosophy and religion of the race. Its complexity became greater and greater, for with more accurate observations came the necessity of adding "cycle on epicycle, orb on orb" to keep track of the required corrections. It is not surprising, therefore, to find Alphonso X., in the thirteenth century, when contemplating the system, exclaiming, "if the Deity had called him to His councils at the creation of the world, he could have given Him good advice." Indeed the system finally crumbled and fell from the very weight of its superstructure.

We have spoken of the ravages of time and of war as hindering the progress of knowledge. We have now to note the greatest calamity that has in modern history overtaken the cause of human knowledge. In the third century before Christ, was founded the Alexandrian library with its treasures of art, of literature and of science collected from every part of the known world. Century by century it grew, and could it have survived what untold treasures would have been ours to-day! But in the seventh century A.D. the Caliph Omar in a day reduced to ashes this storehouse of wisdom, and by one act set the world back a thousand years. Perhaps this disaster can be overrated; perhaps, in the dissemination of copies of the old masters, the Alexandrian library had done its real work; but to me it seems otherwise; for many a priceless gem of literature and of science must have perished in the wanton Arab's destruction. As a single example, it is doubtless due to this cause that we have none of the astronomical writings of Hipparchus.

To Alphonso X., of Castile, belongs the honor of being the first European monarch to foster astronomy. In the thirteenth century he founded a college in Toledo, and gathered together savants from all parts of his realm. From the Arabs they acquired much both in mathematics and in astronomy. Original sources were also sought out in the Greek. Other schools were rapidly established and centers of

scientific culture formed. Among the notable workers and thinkers of the thirteenth and fourteenth centuries were Roger Bacon (1214–1292) in Cambridge and Paris, John Müller of Königsberg (1436–1476), and Leonardo da Vinci (1452–1519), the artist philosopher of Florence. In the early part of the sixteenth century the illustrious Copernicus appears (1473–1543). Copernicus, or Copernic, had a keen mind and a firm belief in what may be called the simplicity of nature. On examining the Ptolemaic system he was embarrassed by its epicycles and excentrics, producing, as they did, complexity where he believed there should be simplicity. He, therefore, turned with relief to the ancient ideas of Pythagoras, and of his system he says:

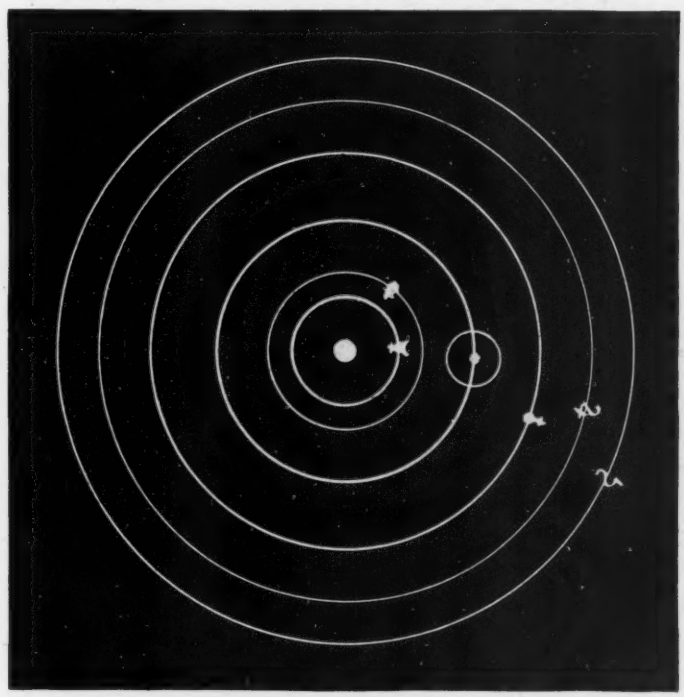
> The several appearances of the heavenly bodies will not only follow from this hypothesis, but it will so connect the order of the planets, their orbits, magnitudes and distances, and even the apparent motion of the fixed stars, that it would be impossible to remove one of these bodies out of its place without disordering the rest and even the whole universe also.

Under the hand of Copernic this system was elaborated and shaped so as to acquire a dignity equal to that of the older system, and, but

for the retarding hand of superstition and bigotry, the dawning day might have rapidly advanced.

As it was, Copernic, fearful perhaps of the fate of Roger Bacon, taught in private a few select pupils, and only on his death bed did he see his printed work (1543). Copernic's sudden death was all that saved him from the hands of his enemies. As it was, his book was soon proscribed and his theory placed under the ban of the church.

With the printing of Copernic's work the battle between the *geo-centric* and *helio-centric* hypotheses may be said to have been fairly joined. Copernic himself foresaw the coming conflict. He also saw



THE SOLAR SYSTEM AS CONCEIVED BY COPERNICUS.

that the real conflict would be, not with astronomers, but with churchmen. In the dedication of his book he says:

> If there be some babblers who, ignorant of all mathematics, take upon them to judge of these things, and dare to blame and cavil at my work, because of some passage of Scripture which they have wrested to their own purpose, I regard them not, and will not scruple to hold their judgment in contempt.

Sir Oliver Lodge, in summing up the life-work of this pioneer of science, says:

> We are to remember, then, as the life-work of Copernicus, that he placed the sun in its true place as the center of the solar system, instead of the earth,

that he greatly simplified the theory of planetary motion by this step . . . which he worked out mathematically . . . and, that by means of his simpler theory and more exact planetary tables, he reduced to some sort of order the confused chaos of the Ptolemaic system, whose accumulations of complexity and of outstanding errors threatened to render astronomy impossible by the mere burden of its detail. There are many imperfections in his system, it is true, but his great merit is that he dared to look at the facts of nature with his own eyes unhampered by the prejudice of centuries. A system, venerable with age and supported by great names, was universally believed and had been believed for centuries. To doubt this system, and to seek after another and better one, at a time when all men's minds were governed by tradition and authority, and when to doubt was sin—this required a great mind and a high character. Such a mind and such a character had this monk of Franenburg.

Mr. E. J. C. Morton in a biography of Copernic says:

Kopernicus can not be said to have flooded with light the dark places of nature—in the way that one stupendous mind subsequently did—but still, as we look back through the long vista of the history of science, the dim, Titanic figure of the old monk seems to rear itself out of the dull flats around it, pierces with its head the mists that overshadow them, and catches the first gleam of the rising sun,

"... like some iron peak, by the Creator
Fired with the red glow of the rushing morn."

It is not to be supposed that there were not weighty objections to be urged against the Copernican system. Of these three may be noted:

1. If it be true that the earth moves, why do not the configurations of the stars change with the changing seasons? It is evident that the grouping of the stars depends upon the distance of the earth from them, and if the earth moves the groups of stars in front of the earth's motion should appear to open out while those behind should appear to close up. We now know the correct answer, that is, that the 184 millions of miles making up the diameter of the earth's orbit is lost in the immensity of stellar space and its effect can only be detected by the most refined of modern methods.

2. If the earth moves about the sun, Mercury and Venus should show phases as does the moon.

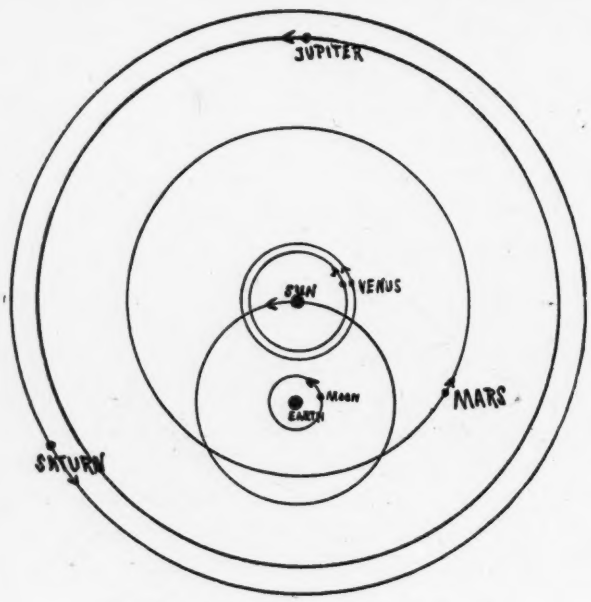
The only answer Copernicus could make was that, were the powers of man's eyesight sufficiently increased, this would doubtless be found to be the case. Seventy years later, Galileo furnished the required proof.

Before looking so far ahead, two important workers must be noted. The first of these is the Danish astronomer, Tycho Brahé (1545–1601), who is well called the father of instrumental astronomy. His aid in the solution of the present problem did not consist in the advocacy of the Copernican system—for he rejected it—but in his patient, faithful gathering of data. His tables of planetary motions and his star tables were the most extensive and the most accurate of his time. Even when

judged by the standards of to-day they are to be viewed with respect. When we remember that the telescope and microscope were then unknown, respect rises to admiration and wonder. So careful was he that not a single mistake due to carelessness has ever been detected in his work.

From 1576 to 1597 Tycho Brahé worked in his well-equipped observatory at Uraniburg on the island of Huen. For twenty years this temple of science was the greatest center of its sort in Europe. Philosophers, statesmen and even kings visited him in his island home. Year by year the great tables of observations grew until further additions seemed but repetitions of oft-told tales. Indeed, the tables grew beyond the ability of their maker to interpret, and some keener mind was needed to unfold their hidden meaning. The possessor of such a mind was even then living in Austria in the person of John Kepler.

John Kepler was born and reared in poverty, and all his life had to struggle to keep actual want from the door. There could scarcely be a greater contrast than that presented by these two men: Brahé, the favored son of fortune, possessing all that wealth and princely favor could procure, acknowledged as the foremost philosopher of his day; Kepler, with nothing to commend him to notice save a passion for knowledge and longing to learn the hidden meaning of equations and formulæ and mystic numbers. The common bond between them was the love of the truth and the capacity for taking infinite pains. For the progress of the race each of these men needed the other, and dame fortune's immediate problem was the bringing them together.




GEOCENTRIC SYSTEM AFTER TYCHO BRAHÉ

By so doing it would be possible for Brahé to pass on to Kepler the completion of his own work, and at the same time train him for an even greater task.

In 1590 James I., of England, visited Denmark and spent eight days with Tycho and his wonderful instruments. On leaving he presented the astronomer with various gifts, and among these was a pet dog of which the astronomer became very fond. Now this canine became the innocent cause of much trouble to his master, for it seems that one day the chancellor of Denmark brutally kicked the poor beast. This was too much for Tycho's temper—never very even—and he roundly berated the chancellor for his cruelty. Of course there is more to the story than just this, but at all events Tycho made a powerful enemy.

KEPLER

who, after the death of the king, stripped the astronomer of all his estates and drove him penniless from the kingdom. For two years he was without a home, but in 1599 found refuge and a pension with Emperor Rudolph II., of Bohemia. Becoming established in Prague, he set up his instruments, and soon students flocked to him again. Among them came the poor youth, Kepler, who soon made himself invaluable to his master. In return, Tycho was kind to Kepler, and together they labored until the former's death in 1601.

With the advent of Kepler (1571–1630) the real problem of gravity together with its solution took definite form. Always a firm believer in the unity and simplicity of the solar system, Kepler rejected the teaching of Tycho Brahé and adopted Copernicus's scheme in toto. Next, he set about bringing order out of the mass of observations ac-

cumulated (for the most part) by Brahé. He took infinite pains, testing by actual calculation every hypothesis or rule that he could think of. For example, he tried circular orbits with constant velocities for the planets and the sun at the center. Finding that this did not fit the facts, he placed the sun a little off center and tried again, but the theory did not yet fit the observed facts. "After incredible labor, through innumerable wrong guesses, and six years of almost incessant calculation" the truth began to dawn upon him, until he was able to enunciate three laws which have since gone by his name. The first of these to yield itself to his zeal was the so-called second law which gives the rule governing the velocity of the planet in its orbit.

Law II., *The radius vector sweeps out equal areas in equal times.* Having determined, as he believed, the law of speed, he next inquired into the exact shape of the orbit. Here "however, the geometrical and mathematical difficulties of calculation threatened to become overwhelming," and as the days dragged into months he had every reason to become disheartened. By day he worked, by night he dreamed of his problem, and it is said that the hint which led to its solution came to him as he slept and awoke him. Arising at once, he lighted his lamp and set to work anew at his calculations. Step by step he progressed, and finally, in a paroxysm of delight, he proved what is now known as Kepler's first law.

Law I., *The planets move in ellipses with the sun at one focus.* To these two laws Kepler nine years later in 1618 added a third.

Law III., *The square of the time of revolution of each planet is proportional to the cube of its mean distance from the sun.*

In these three statements Kepler brought order out of chaos and reduced to system a heterogeneous mass of observations and records. When we remember that these laws of Kepler's furnished Newton not only a point of departure, but also gave him a criterion by which to test his results, we begin to see that without Kepler, Newton might not have been possible. Lodge says of him:

> A man of keen imagination, indomitable perseverance and uncompromising love of truth, Kepler overcame ill-health, poverty and misfortune, and placed himself in the very highest rank of scientific men. His laws so extraordinarily discovered introduced order and simplicity into what else would have been a chaos of detailed observations; and they served as a secure basis for the splendid erection made on them by Newton.

While Kepler was laying the enduring foundations of the Copernican theory, Galileo (1564–1642), was carrying on an open propaganda in Italy. In 1609 he perfected the telescope, and with it, night by night, questioned the heavens. The mountains on the moon, the satellites of Jupiter, sun-spots, the strange appearance of Saturn due to its rings, the changing phases of Venus, were discoveries rapidly

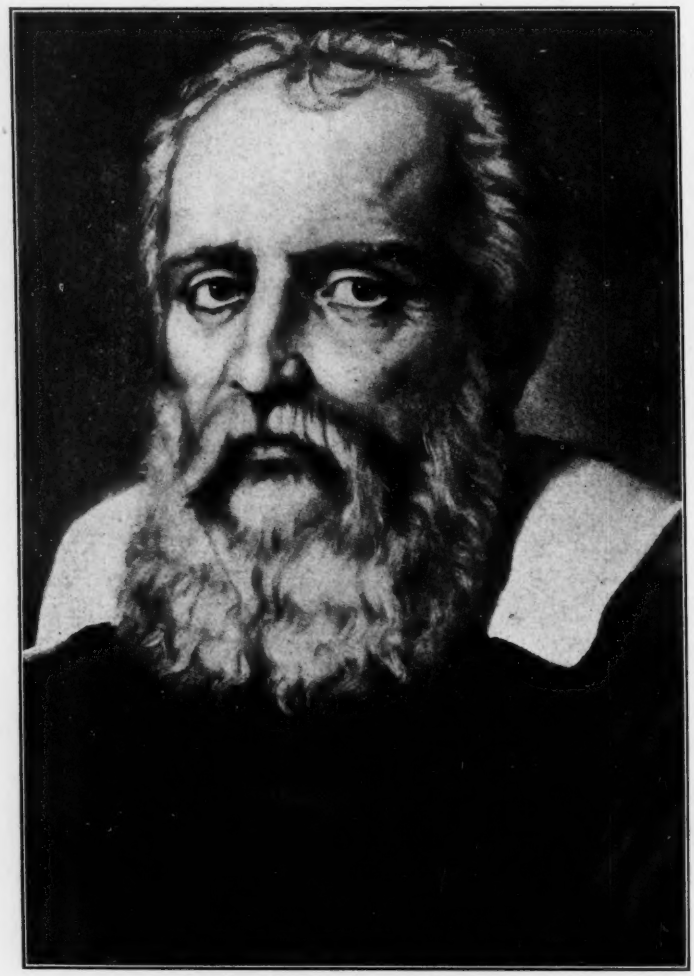
announced to an astonished public. Some of the discoveries, such as those relating to Saturn and Venus, were of such an astonishing and revolutionary nature that Galileo first published them in the form of anagrams. The one announcing the phases of Venus, when deciphered, reads as follows: "Cynthiæ Figuras Æmulatur Mater Amorum." Freely translated: "Venus emulates the phases of the moon." The immediate result of Galileo's brilliant work was to convince all unbiased minds of the truth and to array the church in solid phalanx against both him and his system. Of Galileo personally we have not time to speak—suffice it to say that he was made to suffer most cruelly for his beliefs.

In the year he died (1642) was born—on Christmas Day—the man

who was destined to establish forever the truths for which so many had toiled and suffered before him.

We have tried to follow one of the lines of succession leading up to Newton, giving, as it were, his pedigree upon the side of astronomy. It is a noble line: Pythagoras, Eratosthenes, Hipparchus, Ptolemy, Copernicus, Brahé, Kepler, Galileo, with many lesser names unmentioned. There is another line of succession to be traced, and to this I invite your attention for a brief moment—for I have kept you all too long from the main theme of the paper.

In the study of mechanics as in the study of astronomy we must begin with the Greeks. Thus, we find Aristotle attempting to teach the law of falling bodies, and also giving the reason why heavy bodies



GALILEO.

sink while light ones arise. All his statements relating to mechanics are erroneous and some are positively childish.

The first real student of mechanics was Archimedes (287–312 B.C.) To him we owe the foundations of the science. For example, to him we owe the theory of the lever, from which he developed the idea of the center of gravity. He was especially interested in the subject of hydrostatics, and established principles that are of universal application to-day. His practical applications are best illustrated in the engines of war which he devised to aid in the defense of Syracuse. So effective were these that the Romans took the city not by assault but by starvation. For fifteen hundred years thereafter practically no advance was made. In 1452 the Turks took Constantinople, and fugitive Greeks

HUYGENS.

carried Greek manuscripts westward to Europe. These stray documents gave a fresh impetus to science as they did to letters. The first one really to grasp the subject of mechanics and develop it was Galileo (1564–1642). To him we owe the true theory of falling bodies, the law of the pendulum, the theory of projectiles and two of the three great laws of motion, which were put into their final form by Newton himself.

Two stories about Galileo will serve to show what manner of man he was and also to illustrate his methods. In 1583, while worshipping in the cathedral in Pisa, he chanced to notice the swaying of the great chandelier, the lamps of which had been freshly lighted. From watching its stately vibration he fell to timing it, using as a standard his pulse-beat. Thus there dawned upon him one of the laws of the pendulum—that the time of vibration is independent of the arc of motion. How many thousands of times had that same chandelier been observed

swinging to and fro, and yet it had awaited the coming of Galileo to read its inner meaning!

On the question of falling bodies Galileo ran counter to Aristotle. That philosopher had taught that bodies in falling acquire velocity in proportion to their weight. Galileo found by a simple but careful study that all bodies acquire the same velocity in falling. With the imprudence of youth he forthwith proclaimed the errors of Aristotle from the house-tops, much to the scandal of his classical friends. In answer to their protests he proposed an experiment, and this experiment was made. The faculty of the University of Pisa together with the interested or curious of the city gathered at the leaning tower—"Pisa's leaning miracle," as Whittier calls it. From the top and at the overhanging side Galileo let fall a one-pound and a one-hundred-pound shot. The two shot started, fell—and struck the ground together. As Lodge exclaims, "The simultaneous clang of those two weights sounded the death-knell of the old system of philosophy and heralded the birth of the new." And yet, it is recorded that while some saw, and were convinced, others—nor is their race extinct to-day—saw, but, consulting their copies of Aristotle, disbelieved.

Following in Galileo's foot-steps—perhaps more cautiously lest he be made to suffer for it—Huygens (1629–1699) further developed and extended the science of mechanics. In particular may be noted his development of the theory of circular motion; the invention, or at least perfection, of the pendulum clock, and the determination of the acceleration of gravity from pendulum observations, a method which is to-day the most accurate one in use. Huygens shares with Galileo all the honors due a scholar and original worker of the first rank. They resemble each other in character, in method and in the great value of their labors.

As bearing upon the law of gravitation the theory of circular motion was of the very greatest value. Without it, Newton must either have failed in his task or have discovered these principles for himself. As a matter of fact he did the latter. Huygens was also the first to grasp the significance of the following occurrence. In 1671 Jean Richter, in the course of astronomical work, carried a pendulum clock from Paris to Cayenne in South America. The clock kept correct time in Paris, but at the latter station it daily fell two and a half minutes behind mean solar time. The pendulum was shortened to correct it, but on returning to Paris it was found to gain time at the same rate that it had before lost it. Huygens at once correctly explained this as due to the rotation of the earth on its axis; thus furnishing the first experimental evidence of the earth's rotation.

The span of Galileo's life was from 1564 to 1642. He died discredited by his church, deprived of his liberty and afflicted with blind-

ness. His enemies thought that they had vanquished him and his ideas. They even attempted to blot out his memory from among men by refusing to allow his grave to be marked. How little they knew! Already through Huygens the new knowledge had made great advances; and in the very year of Galileo's death was born the man whose mighty intellect was to flood with light the dark places of nature and to carry Galileo's work to a proud completion.

The year 1660 was in England an important year for science. This is the year of the founding of the Royal Society, and in the same year Isaac Newton, a young man of eighteen, entered the University of Cambridge from the town of Woolsthorpe in Lincolnshire. In 1663 the society received a royal charter, and some time after King Charles is said to have sent it a weighty problem with which to test its powers. "Why is it," said the king, "that the same fish weighs less when alive and swimming in a pan of water, than when dead and floating on its surface?" There must have been rapid improvement in the caliber of its meetings, for in 1665 its members are listening to Robert Boyle's brilliant papers on the air-pump and the barometer.

In the meantime, Isaac Newton, destined for twenty-five years to be president of the society, was pursuing his studies at Cambridge and in 1665 was given the A.B. degree. This and the following year were the years of the great plague. For a time the Royal Society took refuge in Oxford, while the University at Cambridge was, in the fall of 1666 "sent down," the students and faculty scattering to escape contagion.

Newton returned home, his mind teeming with new ideas and hard problems. He had already mastered the most advanced scientific works of his time—Kepler's "Optics," Descartes's "Analytical Geometry" and Wallis's "Arithmetica Infinitorum." In reading, Newton was in the habit of noting what seemed to him capable of improvement. At this time (1666) he had already projected experiments in optics which were to be the first of his achievements to make him known to the world. In mathematics he had originated the binomial theorem and had laid the foundations of the infinitesimal calculus. Armed with this new weapon of analysis, Newton pushed his mathematical researches in many directions, solving with ease problems that had so far baffled attack. Whatever he touched turned to gold under his hand. So rapidly did his mind work that he seems not to have needed to work out each step in detail; his printed papers sometimes read like a list of answers to difficult propositions. For example, he presents a classification of cubic curves, giving seventy classes in all. Yet in all this list there is no suggestion of the process by which the results were obtained. Among the books that Newton read was Galileo's "Dialogues on Motion," and here as elsewhere he found abundant material for work. In this field of mechanics his mind worked with its usual clearness and

rapidity. He restated the laws of motion in such clear and simple terms that for two and a half centuries no word or line has been changed. Bringing to bear his new calculus he readily solved the problem of falling bodies, and in 1666 discovered the laws of circular motion, seven years before they were published by Huygens in 1673.

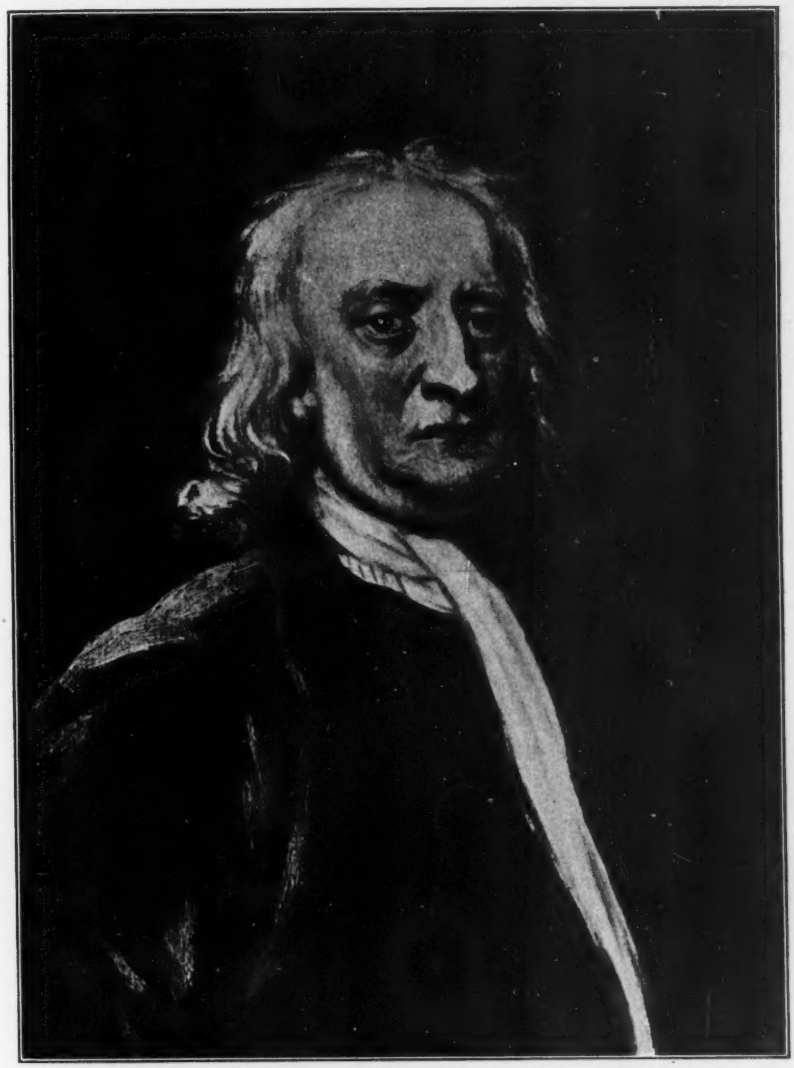
To such a wide reader and deep thinker as Newton, the problem of "gravity" would appeal with keen interest. It would have been but natural that he should have gathered together all that was available of the literature of the subject. Thus he was familiar with Kepler's views expressed in the following citation:

> The true theory of gravity is founded on the following axioms. Gravity is a mutual affection between cognate bodies toward union or conjunction, similar to the magnetic virtue. . . . If the moon and the earth were not retained in their orbits by their animal force or some other equivalent, the earth would mount to the moon by a fifty-fourth part of their distance from each other, and the moon would fall toward the earth through the other fifty-three parts, that is, assuming that the substance of the earth is of the same density. . . . The sphere of the attractive virtue which is in the moon extends to the earth and entices up the waters, but as the moon flies rapidly across the zenith and the waters can not follow so quickly, a flow of the ocean is occasioned toward the westward. If the attractive virtue of the moon extends to the earth, it follows, with greater reason, that the attractive virtue of the earth extends to the moon and much farther, and, in short, nothing which consists of earthy substance, however constituted, although thrown up to any height, can ever escape the powerful operation of this attractive virtue.

Borelli (1608–1679) also expresses views no less explicit, and, in his work, "On the Satellites of Jupiter," distinctly attributes the revolutions of the heavenly bodies to the force of gravity. So also Bullialdus wrote "that all force respecting the sun as its center, and depending upon matter, must be in a reciprocally duplicate ratio of the distance from the center." This last sentence is quoted from one of Newton's letters, and shows how carefully he had read on the subject.

Of Newton's immediate contemporaries, Robert Hooke and Edmund Halley were actively working in this field. Hooke (1635–1702) especially is ambitious to secure the honor of the solution of the problem the answer to which he reads almost exactly right, but the proof of which—poor man—he can not give. Failing in the demonstration himself, he talks on the subject, about the subject, and all over the subject, in the meetings of the Royal Society, in his papers and in his letters. So full of it is he that he imagines that whatever any one else does is stolen from him. Finally Sir Cristopher Wren offers him a prize if in two months he will produce the boasted of solution. None is forthcoming and history must write Hooke down as a most ardent worker and ingenious man, but as totally unequal to the great task imposed upon Newton.

Halley is more modest; he applies the laws of circular motion published by Huygens in 1671, sees clearly that the law of inverse squares

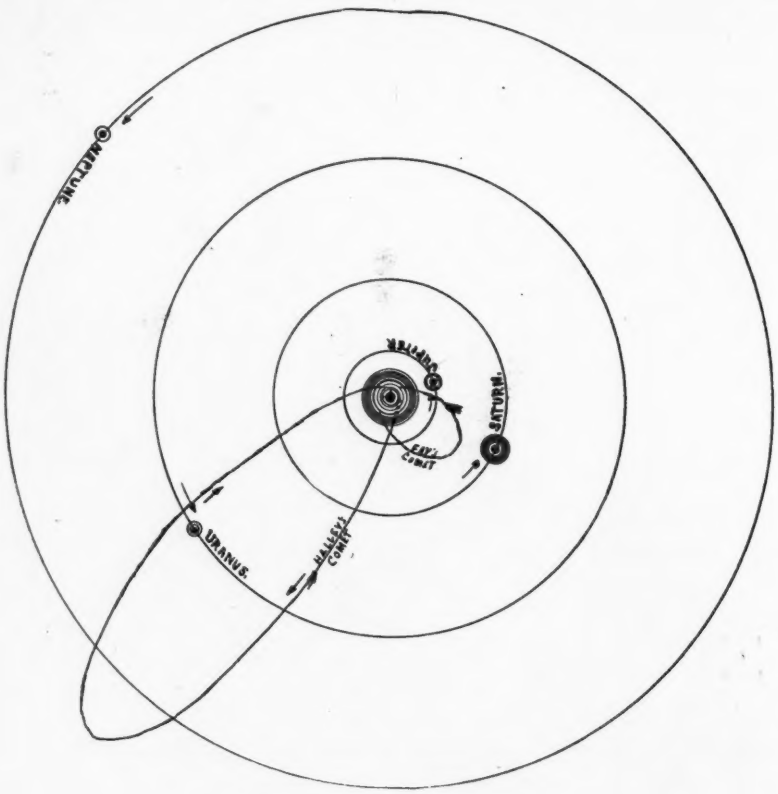


NEWTON.

must hold good, does hold good for the circular orbit; sees also from Kepler's third law that if it can be applied to the elliptical orbit as well then all the planets immediately fall into that celestial harmony predicted by Pythagoras two millenniums before. The law holds for the circle, does it not hold for the ellipse also? We can imagine with what nervous eagerness Halley argues the question with Wren and Hooke and then—Heaven-inspired thought—posts him down to Cambridge to consult Newton. This was in August, 1684.

We must now rapidly review Newton's own work during the twenty years following his graduation from Cambridge in 1665. From the

very beginning he was interested in this particular problem of gravity, but it was only one of many. Moreover, his was not a mind to stop short of the full and complete solution. This force of gravity—if it be this force that governs the universe—must be expressed by an exact law; he sees more clearly than any one else what is involved. So he ponders over the problem, and one day—would that we knew the date—he is seated in his garden studying, beside him his books and papers. In the sky is the pale moon and as Newton gazes upon her he ponders




SOLAR SYSTEM AFTER NEWTON.

on the world-old problem, this riddle of the ages. What force holds that moon forever circling about the earth? An apple falls to the ground beside him and its thud awakens a train of thought in his mind. Can it be the same force in the two cases—is the moon but a larger apple forever falling toward the earth, urged by the force of gravity, and forever receding from the earth, urged by her own uniform motion? Fascinated by the thought, Newton sets to calculating. He has studied out the laws of uniform motion and of accelerated motion—now he combines the two and gets the law of circular motion. He draws a

circle to represent the moon's orbit and calculates by what amount the moon ought to fall toward the earth in a minute, assuming that its distance from the earth is that given in the books. In his own words he finds the figures "to answer pretty nearly." But this does not satisfy him; to a mind like Newton's "pretty nearly" is as bad as "not at all," so he lays aside his papers until more exact data are at hand. He has, however, made the first stage of the journey toward the goal. This was in the plague year, 1666. As soon as the university is again convened, Newton returns to Cambridge and for a number of years is engrossed in the study of optics. In 1672 he is momentarily reminded of the problem while editing a revised edition of Varenius's "Geography." In this he gives the accepted value for the earth's degree sixty-one and one half miles. This was probably the value Newton used in his calculations of 1666 and which fitted "pretty well," as he said. In 1679–80 Newton has an unwilling and one-sided correspondence with Hooke relating to the theory of projectiles, and in which the subject of gravity is involved.

We may be sure that during these years Newton had many times analyzed the grand problem of solar gravity and had carefully noted just what was involved therein. We may even venture to note what must have been his thoughts. If, he would say to himself, it be gravity that rules the motion of the moon, then I must prove the following:

1. Gravity must act on all kinds of matter alike, for the earth is a composite body, and presumably the moon also.

2. We know with a fair degree of accuracy that the moon is sixty-one earth-radii from us, but to make any calculation, this distance must be known in feet. Hence it is important that measurements of the size of the earth be made with the greatest care.

3. The same law should extend to the planets also, but the planetary orbits are ellipses, hence I must prove that the ellipse is a possible or necessary orbit under such a law of force.

4. I must determine some point from which measurements of distance between earth and moon are to be made, *e. g.*, shall it be from the centers of these bodies? Also, does the same law of force hold good over the whole distance, or is it modified as the surface of the earth or moon is approached?

Whether or no Newton set the matter in orderly array, it is clear from his papers and letters that each of these points was considered. Thus he proves the first point by an exhaustive series of experiments on pendulums in which he varies the material of which the pendulum is made, proving clearly, "by experiments made with the greatest accuracy, the quantity of matter in bodies to be proportional to their weights." The converse must also be true—the weight or pull of gravity on bodies is proportional to their mass or quantity of mat-

ter.[1] The second point Newton did not himself attack, but in 1682, when attending a meeting of the Royal Society in London, he heard of Picard's recent measurements of the earth's degree. On returning to Cambridge he inserted the new value in his old calculations of 1665, measuring the distance from earth center to moon center. Finding as he advanced that the result was manifestly going to produce the long-wished-for answer, he found it impossible—so the story goes—to proceed. With the aid of a friend the calculation was completed, and Newton had reached another milestone on the way towards his cherished goal. The figures tally exactly—has he not solved the problem and may he not proclaim the answer to a waiting world? None but Newton knew the distance yet to be traveled before complete success should be his. Nothing short of this could satisfy his truth-loving mind, and the world must wait. The third point may be stated thus: "Given a central force varying as the inverse square of the distance, show that the orbit is an ellipse with the force-center at one focus." This Newton did before the year 1684, for in August of this year, when Halley, disgusted with Hooke's bombast, came to Cambridge, he asked Newton without delay the following question: "What path will a body describe if it be attracted by a center with a force varying as the inverse square of the distance?" To this Newton at once replied, "An ellipse with the center of force at one focus." "How on earth do you know?" exclaimed Halley in amazement and delight. "Why, I have calculated it," and Newton rummaged for the paper. Failing to find it, he promised to forward it to Halley by post. This promise Newton fulfilled in November. It is not known how much ground was covered in this paper, but, of course, the desired demonstration of the third point above noted was given. Newton must now have realized that he must solve the fourth point and thus complete the work so nearly finished. Something of this may have been expressed in his letters to Halley, for in December, 1684, Halley again visited him and urged him to continue his investigations. Thus far he had shown that Kepler's laws called for the inverse square law of gravity—that Picard's value of the earth's radius fitted exactly into the theory. It but remained to prove that he is correct in taking the distance from center to center of the earth and moon. For weeks and months he works over this proof and finally, some time in 1685, it yields to his unremitting toil. The approximate date of the achievement we know from a letter of Newton's to Halley dated June 26, 1686, in which he says, "I never extended the duplicate proportion lower than to the superfices of the earth, and before a certain demonstration I found the last year, have suspected it not to reach accurately enough down so low." The answer, mathematically proved in Prop. LXXIV. of Book I. of the "Principia,"

[1] "Principia," Book II., Prop. XXIV., Theorem XIX.

is that a sphere attracts all outside bodies as if its mass were concentrated at its center.

Thus he reached his goal at last, and after twenty years of work, ranging over many subjects, the key of the universe lies in Newton's hand. Surely, now, he will publish it and proclaim its discovery to the world. Not so; he must first have the joy of undisturbed possession. Also there is much more to be done. The law he has proved is an "open sesame" to wider knowledge. Or, to change the figure, it is as if a mountain climber, who has toiled upward and upward, now stands at last on the topmost height. As he is climbing he thinks that if he can but gain the summit it will be enough—he will be content and rest. The toiling climber does not realize what awaits him at the top, until the whole panorama of plain and mountain, of crag and canyon, bursts upon his astonished sight. With this before him he forgets his toil, forgets to rest and devours the view. So with Newton, having at last mastered the central law upon which the universe swings, he saw the members of the solar system sweeping in orderly grandure through space, he saw this law governing every motion of every satellite and comet, accounting for the nutations and perturbations, which before seemed to make order impossible. He saw it causing the tides with the rising and setting of the sun and moon. All this and more he saw, and we can not wonder that instead of rushing into print, he shut himself up and worked and thought and wrote, and calculated and worked and thought and wrote.

For two years he labored, sleeping little, eating little, always lost in thought. Often, it is said, on rising, he would sit for hours half dressed upon his bedside. Often for days, he would seem oblivious to all external events. The following story well illustrates his abstraction. One day a friend, Dr. Stukely, called and found Newton's solitary dinner ready on the table. After waiting a long while, Dr. Stukely thought to play a joke on Newton, which he proceeded to do by eating his dinner for him. Having done so, he rearranged the table, covering the dishes so that it would not appear that anything had happened. At length Newton appeared, and, after greeting his friend, sat down to dinner, but, on lifting the cover, said in surprise, "Dear me! I thought I had not dined, but I see I have."

So it went on for two full years, until Newton felt that his work was done. He divided it into three books. The first is entitled The Mathematical Principles of Natural Philosophy, and comprises about two hundred and fifty pages. It reminds one of a geometry, with its propositions, theorems, scholiums and problems. The first book is divided into fourteen sections and contains ninety-seven propositions, fifty theorems and forty-seven problems. Book II. discusses The Motions of Bodies. Here are found fifty-three propositions, forty-one

theorems and twelve problems. Book III. has fewer diagrams, less mathematics and more discussion. The principles of natural philosophy are applied to the explanation of the solar system, and such topics as comets and tides are carefully treated. There are forty-two propositions, twenty-two problems and twenty theorems. The whole work covers 507 printed pages, and has a total of 192 propositions, 113 problems and 79 theorems, besides lemmas and scholiums in abundance.

Oliver Lodge in an outline of the "Principia" selects seventeen points for special emphasis. Of these a few may be reviewed.

1. Newton shows from Kepler's laws the following: (*a*) From the first law, that the law of gravity is inversely as the square of the distance. (*b*) From the second law, that this force is directed toward the sun as center. (*c*) From the third law, that all the planets are acted on by the same law of gravity; *i. e.*, that the law of gravity extends to the uttermost confines of the solar system.

2. From the length of the year and the distance of any planet from the sun Newton calculates the planet's mass, using the earth's mass as a unit.

3. He recognized the comets as members of the solar family and showed how to calculate their orbits.[2]

4. He showed that the earth, as a result of its rotation, must be flattened at the poles, and calculated the amount (28 miles).

5. He laid the foundation for a complete theory of the tides.

We have but noted the high lights, as it were, of Newton's work. No wonder that he became lost to external events as his mind grappled with problem after problem, and one by one lay bare the secrets of the universe. As an example of the style in which the "Principia" is written, we may quote from the beginning of the third book where he lays down rules for reasoning in philosophy:

> *Rule I.* We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances. To this purpose the philosophers say that nature is pleased with simplicity and affects not the pomp of superfluous causes.

The "Principia" was finished in the spring of 1686. It was published by order of the Royal Society, being issued from the press in July, 1687. Newton, from being a little-known member of the faculty of Cambridge, was at once recognized as the foremost scientist of the world. Honors were showered upon him. He was sent to parliament. He was elected president of the Royal Society. The queen made him a knight of the realm. He was given a lucrative position under government and moved to London. His work for science was finished, and for forty years he reaped the reward of his labors.

[2] The first cometary orbit to be calculated was done by Halley upon the comet bearing his name, which last year made its third return since Newton's day.

What Newton accomplished in optics and in mathematics would entitle him to high rank in the world of science. Of his work in mathematics the German scholar, Leibnitz, said, "Taking mathematics from the beginning of the world to the time when Newton lived, what he had done was much the better half."

The work included in the "Principia" was most of it done between 1680 and 1686. By far the greater part was done during the last two years of this short period, or between the forty-second and forty-fourth years of his age. This work, in its scope, in its far-reaching importance, and in the order of mind required for its accomplishment, raises Newton not merely to the first rank of the world's great minds, but compels the world to admit no second in his class. His genius shone resplendent even in his own day. We have already quoted Leibnitz. A French admirer wrote to an English correspondent, "Does Mr. Newton eat, drink, sleep like other men? I picture him to myself as a celestial genius, entirely removed from the restrictions of ordinary matter." Says Lagrange (1736–1813), a great French mathematician, "Newton was the greatest genius that ever existed, and the most fortunate, for we can not find more than once a system of the world to establish." The English writer, Whewell (1794–1866), writes, "The (Law of Gravitation) is indisputably and incomparably the greatest scientific discovery ever made, whether we look at the advance which it involved, the extent of truth disclosed, or the fundamental and satisfactory nature of this truth." Pope in a striking epigram expresses the same thought:

> Nature and Nature's laws lay hid in night;
> God said, Let Newton be, and all was light.

La Place, who did much work along the lines laid down by Newton, says of the "Principia": "The universality and generality of the discoveries it contains, the number of profound and original views respecting the system of the universe it presents, and all presented with so much elegance, will insure to it a lasting preeminence over all other productions of the human mind."

Sir Oliver Lodge says of Newton: "In science the impression he makes upon me is only expressed by the words 'inspired,' 'superhuman.'"

Of his own work Newton says: "I know not what the world will think of my labors, but to myself it seems that I have been but as a child playing on the seashore; now finding some pebble rather more polished, and now some shell rather more agreeably variegated than another, while the immense ocean of truth extended itself unexplored before me." When asked how he made his discoveries, he replied: "By always thinking unto them. I keep the subject constantly before me, and

wait till the first dawnings open slowly by little and little into a full and clear light." Commenting upon this somewhat modest remark Lodge says: "That is the way—quiet, steady, continuous thinking, uninterrupted and unharassed brooding. Much may be done under these conditions; much ought to be sacrificed to obtain these conditions. All the best thinking work of the world has been thus done."

In closing, let us pause and consider the state of knowledge before and after Newton. Before him are the foreshadowings of Copernicus, the dim gropings of Kepler, the elementary truths of Galileo, the flashes of Borelli and Huygens, the fantastic speculations of Descartes; after him is a magnificent and comprehensive system of well-ordered knowledge. As we contemplate this we can understand the significance of the inscription on Newton's tomb. "Let mortals congratulate themselves that so great an ornament of the human race has existed."

# EDWARD PALMER[1]

By WILLIAM EDWIN SAFFORD

> Than longen folk to gon on pilgrimages,
> And *palmers* for to seken straunge strondes.
> *Chaucer*, Gen. Prol. to Canterbury Tales.

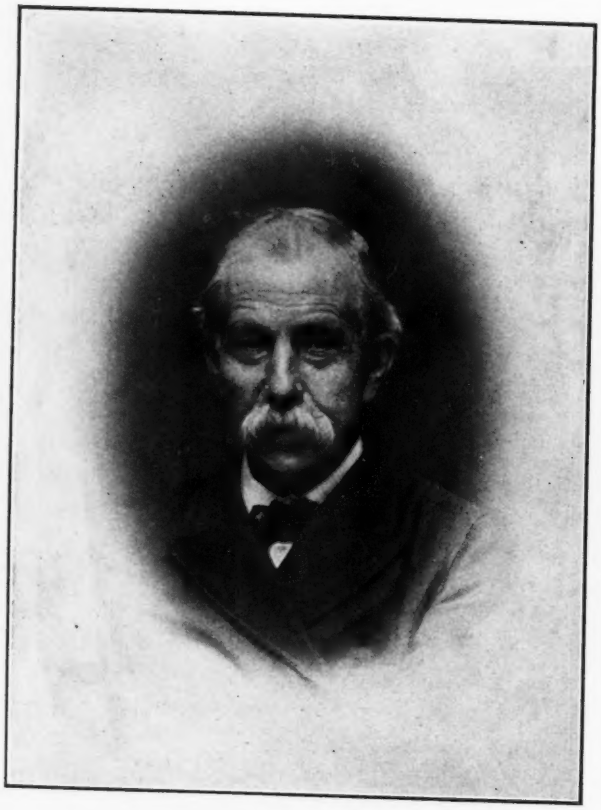
EDWARD PALMER is a man well named. A palmer of the olden time was one who had traveled to the Holy Land in fulfilment of a vow, and brought back with him a palm branch to be placed on the altar of his parish church. Afterwards the name was applied to pilgrims who traveled unceasingly from land to land, under a perpetual vow of poverty and celibacy.

This is what our Palmer has done. From the age of early manhood until now, the winter of his life, never content to remain inactive even for a short period, he has set out upon one pilgrimage after another, bringing back many palm branches and other strange and beautiful products of distant climes, reverently to lay them on the altar of science.

He is an Englishman by birth, born January 12, 1821, at Hockwold cum Wilton, near Brandon, in the county of Norfolk. His father was a professional florist and horticulturist; so that from his earliest childhood his associations have been with flowers and shrubs and trees. When a youth of eighteen he came to America and settled at Cleveland, Ohio. There it was his privilege to meet with Dr. Jared O. Kirtland, one of the most eminent and respected scientific men of his day, in whom there was combined a peculiar personal charm and magnetism with great zeal for the study of nature.

Dr. Kirtland was not only an accomplished botanist, but a practical horticulturist as well, and a man whose greatest pleasure it was to gather young people about him and instill into them a love for natural history. He was one of the earliest members of the American Academy of Sciences, and in connection with the Geological Survey of Ohio made extensive collections of plants and animals of that state. This kind and learned man found a willing disciple in young Palmer, whom he invited to his home and, inspiring him with the display of his zoological collections and herbarium, taught him to prepare bird skins and to dry and press plants, thus laying the foundation for his future career.

[1] A biographical sketch read at a meeting of the Botanical Society of Washington, D. C., on the occasion of the eightieth anniversary of Dr. Palmer's birth.



Yours Sincerely
Edward Palmer

While in Cleveland Edward Palmer made his home with Hon. John W. Taylor, formerly speaker of the House of Representatives, a man of national reputation, who after a long and active life had become a helpless paralytic and was living in that city with a married daughter. Mr. Taylor was visited by many eminent men, and young Palmer was present at many interesting discussions of current events.

At that time there was much talk of opening Paraguay, the hermit nation of South America, to the outside world. It had not been long since Commodore Perry had knocked at the door of Japan and gained entrance; and the scientific results of the United States Exploring Expedition, which appeared in print from time to time, were frequent topics of conversation. When the United States government decided to send an expedition to Paraguay, young Palmer applied for a position as collector of natural history specimens. A small vessel, the *Water Witch,* commanded by Thomas Jefferson Page, was fitted out for the purpose, and Edward Palmer's name was entered upon its rolls.

His duties at sea were to assist the ship's surgeon in caring for the sick and administering medicines. He was placed in charge of the ship's dispensary and was assigned to various stations at drills and quarters. On arriving in South America he was to collect and prepare specimens of birds, reptiles, mammals and plants, as well as objects of ethnological interest.

The *Water Witch* left the United States in February, 1853, reached the mouth of the Rio de la Plata without accident, and after a short stay at Buenos Ayres proceeded to Asunción, the capital of Paraguay. She then steamed up the river beyond into the territory of Brazil, where much interesting information and material were collected. A history of this memorable expedition and of the war with Paraguay which resulted may be found in Captain Page's work on La Plata.[2] Dr. Palmer's personal notes contain much of vivid interest, and I regret that there is not space in the present paper to give them in detail. It is sufficient to say that he was called upon not only to superintend the delivery of ammunition from the magazine of the vessel, but also to dress gunshot wounds and to attend to the burial of the dead.

No account of the scientific results of the expedition was published. There was no one at the time to identify and describe the plants collected, which for a time were lost; and we come upon them now and then in the collections of the national herbarium, many of them still unnamed.

One of the most interesting episodes of the *Water Witch* Expedition was the meeting of an officer sent from the ship on a reconnaissance with Bonpland, the companion of Humboldt on his travels in America.

[2] Page, Thomas Jefferson, "La Plata, the Argentine Confederation and Paraguay," New York, 1859.

This venerable naturalist had for many years been a prisoner of the Paraguayans, but he was now living like a patriarch on his own plantation, surrounded by a brood of sons and daughters and cared for by a devoted native wife.

On his return to the United States Edward Palmer first went to Cleveland to give his friends an account of his wanderings, and then to England to visit the home of his childhood, as well as the great World's Fair at the Crystal Palace. Coming back to America, he took a course of medical instruction, to supplement as well as possible the practical knowledge he had acquired on the *Water Witch*. He then received an appointment as collector in connection with the Geological Survey of California, working under the direction of Dr. Cooper, especially on the marine invertebrates of the California seacoast. He was thus engaged when the civil war broke out.

In 1862, when President Lincoln called for troops, Palmer returned east and applied for a position as acting assistant surgeon in the army, relying on his past experience as a voucher for his fitness for the work. He accompanied Colonel Leavenworth to Colorado, under the promise of an appointment, but for many months he served without appointment or pay in caring for sick soldiers at various posts. At Fort Lyon there was much sickness among the troops, and he was ordered to relieve the contract surgeon at that post. From this time until the close of the war he was engaged at various posts, often riding with the sick in ambulances, but not resisting the temptation en route to alight and gather up plants, reptiles and other objects which seemed to him of interest; for he was a born collector. One of his last stations was Kansas City, where he assisted the surgeon in the city hospital.

After the close of the war he was stationed at various posts in Arizona and the Indian Territory, where his work of attending the sick was pleasantly varied with his occupation as a collector, sometimes receiving scant sympathy from his commanding officers, sometimes encouraged by them to pursue his work in the cause of science; but always on his detachment from a post carrying with him testimonials as to the faithful performance of his duties, his tender care of the sick, and his remarkable success in using simple herbs and local remedies when his official supply of medicines was exhausted. His personal notes teem with interesting anecdotes, such as an account of a scouting expedition against the Apaches, on which he collected ethnological material while half-breed soldiers were bayonetting and scalping hostile Indians; and the story of his vicissitudes during an epidemic of sickness at Fort Grant, when he himself was stricken. He did not on that account cease to add to his collection, but while he lay in the little hut that served as his dispensary he was aided by a cat that brought in small animals to her kittens. He would seize her gently, take away her prey, and after

removing the skull and skin of the animal, allow her to proceed with its body to her little ones. In this way he secured specimens of several new rodents. He also gives an interesting account of a raid by a party of Indians in the Indian Territory, who were about to destroy his collections, but stopped short at the sight of snake-skins, evidently recognizing them as the property of a medicine man with whom it was dangerous to trifle.

Dr. Palmer's reputation as a collector having been established, he was sent by the commissioner of agriculture, in March, 1869, on a mission to New Mexico and Arizona, to report on the agricultural resources, the commercial products, the climate and fertility of the soil, and the general habitable features of the various localities to be visited by him.

He proceeded to Fort Wingate, N. M., and across the border to Fort Defiance, Ariz., whence he visited the Navajo Indians and the Hopis, or Moquis, of northeastern Arizona. Dr. Palmer in his notes describes the agriculture of the Hopis and gives an account of a feast at which the principal articles of food were thin, scroll-like cakes of blue corn-bread, which were used by the Indians for plates and spoons as well as for food; syrup made from the roasted crowns of an agave; peaches, which the Indians had begun to cultivate; and mutton from their flocks. At the village of Oraibi a rabbit hunt was organized in honor of his visit, and Dr. Palmer for the first time saw boomerangs used as weapons of the chase. Specimens of these were secured for the National Museum. Some of the cactaceæ collected in this region were described by Engelmann, and by Coulter in Vol. 3 of the Contributions from the U. S. National Herbarium.

After his return to Fort Wingate, Dr. Palmer was furnished with an army escort for his journey to Fort Whipple, Ariz. On his way thither he stopped to collect on the slope of San Francisco Mountain, a locality which had never before been visited by a botanist. From Fort Whipple he made various excursions to neighboring localities, securing much botanical material and objects of ethnological interest illustrating the habits and customs of the various tribes of Indians inhabiting the territory of Arizona. This was forwarded to San Francisco, by way of the Colorado River and the Gulf of California. It was shipped at San Francisco on the *Golden City* to go to New York by way of the Isthmus of Panama; but the vessel was lost, with everything on board. Only a collector can realize what a blow this was to Dr. Palmer. "When I heard of the disaster," said he, "every hardship and risk I had endured came to my mind; one by one I recalled some special object of beauty or of interest which I felt I could never replace."

From Arizona he entered the Mexican state of Sonora and proceeded southward to Guaymas, collecting on the way. After visiting the

Yaqui Indians in the interior, he crossed the Gulf of California to the peninsula of Lower California and went thence by sea to San Francisco. Among the plants collected in northern Sonora and along the shores of the Yaqui River, many proved to be species hitherto unknown. One of them, a columnar cactus, had fruit densely covered with spines, which was used by the Indians for brushing their hair. This was named *Cereus pecten-aboriginum* by Engelmann, and afterwards described by Sereno Watson in Volume 21 of the *Proceedings of the American Academy.*

Dr. Palmer next went to Utah. He carried with him a letter of introduction to Brigham Young, who assisted him most willingly in his work by giving him letters to the authorities in the southern part of the territory. His work was chiefly in the vicinity of St. George, in the southwest corner of the territory. This region, considerably lower than the great Utah basin, is remarkable for its semitropical products, such as pomegranates, cotton, etc., on which account it is sometimes called *Dixie Land.* From St. George he made a long and painful journey across what is now the southern corner of Nevada to Hardyville and Camp Mohave, on the Colorado River, and thence across southern California to San Francisco.

On his return to Washington, in November, 1870, he received a letter from Dr. Torrey, congratulating him on the successful accomplishment of his mission. "I had anticipated much pleasure," Dr. Torrey wrote, "in spending several days with you at the agricultural department, and in hearing from you an account of your doings and adventures.

"You have, in the last few years, done great service to North American botany, and I trust that we shall receive yet greater benefit from your explorations. There are many choice plants to be found in our little-explored states and territories.

"I should be delighted to look over your late discoveries, and I hope you will be able to spare me duplicates. It is of great importance that the herbarium of Columbia College should be as complete as possible in North American plants."

The commissioner of agriculture, Horace Capron, in his report for 1870, calls special attention to the collections of Dr. Palmer and states that the botanical material accumulated by him "is now in process of elaboration by the distinguished American botanists, Drs. Gray, Torrey and Engelmann, and includes a considerable number of plants new to science which will be greatly prized by scientific botanists, and eagerly sought by botanical institutions at home and abroad."

"The design of establishing at the seat of government a collection of plants worthy of the name of a national herbarium is thus in process of rapid accomplishment, at a comparatively small cost; and it is confi-

dently expected that this collection, now probably the third in point of size, will eventually exceed all others in the amount and value of its materials for illustrating North American botany."[3]

In the same report was published a paper on the "Food Products of the North American Indians," based upon Dr. Palmer's field notes and observations.

During the next two years Dr. Palmer was engaged in making collections of marine invertebrates and algæ on the New England coast, and in going over his material at the Museum of Comparative Zoology at Cambridge.

From Cambridge, at the suggestion of Professor Gray, Dr. Palmer made a trip to Florida and the Bahama Islands. A list of the algæ collected by him at this time was published by Professor Daniel Cady Eaton, of Yale, but no list of the flowering plants was published. One of the most interesting plants found by him in Florida was a yellow waterlily, *Nymphæa flava,* which had been figured many years before by Audubon, but which had remained unknown except through Audubon's figure until its rediscovery by Palmer. In Audubon's figure the leaves of a *Nuphar* instead of those of a *Nymphæa* had been depicted, and Dr. Palmer's specimens were the first to establish the true nature of the plant.[4]

In 1875 Dr. Palmer visited Guadalupe, an island lying some distance off the coast of Lower California, which had never before been visited by a botanist. His collections on this island revealed a fauna and flora of peculiar interest, connecting it rather with upper California than with the adjacent peninsula. Every bird in his collection except a single sea bird proved to be new to science, though represented by allied forms on the mainland; and among the plants there were twenty-one new species, the greater part of which proved to be peculiar to the island. The account of Dr. Palmer's personal experiences on the island is most interesting, but unfortunately there is not space here to repeat it.

While on the island he lived in a dug-out with a roof of poles covered with dirt. His explorations were attended with much difficulty and for several weeks he was seriously ill. Sometimes in order to secure plants growing on the faces of cliffs, which had been preserved on account of their inaccessible position from the greed of goats, he made use of a noose at the end of a long pole, much to the amusement of the herders, who laughed at the doctor's attempts to "lasoo plants." Many of the species could have been secured in no other way. "Goats," he says, "were my only rivals; but they made a clean sweep of everything in reach, not discriminating between what was common and what was rare."

[3] Report of the Commissioner of Agriculture for 1870, pp. 11, 12, 1871.

[4] See *Am. Journ. Science,* No. 65, 416, 1876.

An account of the vegetation of the island based upon his collection was published by Sereno Watson in Volume 11 of the *Proceedings of the American Academy,* 1876; and a description of the birds by Robert Ridgway in a bulletin of the Hayden Survey.[5]

Immediately after his return from Guadalupe Island Dr. Palmer began to collect botanical and ethnological material in southern California for the approaching Centennial Exposition at Philadelphia. It was at this time that he crossed the boundary line into Mexican territory and made his famous collection of plants in the great canyon of the Cantillas Mountains, in the northern part of Lower California, a locality never before visited by a botanist, which yielded a number of new and interesting species. The collections were of special importance, and added much to the knowledge of the botany of the region. Many of Dr. Palmer's notes were embodied by Gray and Watson in their "Botany of California," which was then in preparation. He also visited the Diegueño Indians of southern California and obtained valuable material illustrating their arts and habits of life; their weapons, baskets, pottery, foods and medicines.

On one of his collecting expeditions near the Lower California boundary line he came upon a party of almost naked Cocopa Indians gathering their annual supply of pine nuts, the fruit of *Pinus quadrifolia.*

"It was an interesting sight," said he, "to see these children of nature with their dirty laughing faces, parching and eating the pine nuts. They had already filled many bags and were eating them by the handful. Indeed we found the piñones to be rich and well-flavored, and we were not satisfied with few. We realized that these happy free people were in their natural habitat here beneath the pines. At last we had the privilege of seeing primitive Americans gathering their uncultivated crop from primæval groves."

Another plant collected by Dr. Palmer proved to be the type of a new genus, which Professor Gray named *Palmerella* in his honor, stating that he did so in acknowledgment of Dr. Palmer's "indefatigable and fruitful explorations of the botany of the southwestern frontiers of the United States, from Arizona to the islands off Lower California, in which region he has accomplished more than all his predecessors."

Dr. Palmer sent a fine collection of woods to Dr. Vasey, who was preparing an exhibit of forest trees of America for the Centennial Exposition.

[5] Ridgway, Robert, "Ornithology of Guadalupe Island, Based on the Notes and Collections made by Dr. Edward Palmer," Bull. Hayden Survey, No. 2, p. 183, 1876. See also by the same author, "The Birds of Guadalupe Island, Discussed with Reference to the Present Genesis of Species," *Bull. Nuttall Ornitholog. Club,* Vol. 2, p. 58, 1877.

The months of November and December, 1875, were spent in southwestern Utah, where he made a collection of the principal plants and the plant products of the Paiutes. An account by Dr. Palmer of "Indian Food Customs" was afterwards published in Volume 12 of the *American Naturalist,* and reprinted in the *American Journal of Pharmacy* in 1878. Several burial mounds in the vicinity were opened by Dr. Palmer, and a valuable collection of pottery, beads, etc., resembling similar objects of Pima and Hopi Indians of Arizona, was made and sent to the National Museum.

From St. George, Utah, Dr. Palmer went to San Bernardino, California, for necessary supplies, and then back to Arizona, where he visited the Mohave Indians of the Colorado River, concerning whose arts and customs he obtained valuable notes, describing their methods of fishing, trapping, pottery-making, food preparing, their navigation on balsas made of bundles of reeds and their primitive methods of agriculture. He also collected a number of living cactaceæ characteristic of the vegetation of the region, including the giant *Cereus,* for exhibition at Philadelphia.

From Camp Mohave he crossed the desert to San Bernardino, discovering on the way a beautiful little plant which proved to be the type of a new genus of the poppy family, and to which Professor Gray gave the name *Canbya.*

On May 29, accompanied by Dr. Parry, Professor Lemmon and Mr. Craft, of Crafton, and several others, Dr. Palmer set out to climb Mount San Bernardino. The next day Dr. Palmer fell from his horse and severely injured his spine. He was obliged to lie until the following day on an improvised bed, when he was carried to the bottom of the mountain to a carriage in which Dr. and Mrs. Parry had come to take him home. In the meantime an account of the expedition had been published at San Bernardino, in which it was stated that the doctor had been left "on the mountain *without grass or water,* with a man to look after him." "Wherever I went for some time afterward," said Dr. Palmer, "I was pointed out as the man who had been left on Grayback Mountain without grass or water; sometimes I was jocosely addressed: 'Hello, old grass-and-water, how's your back?'"

Dr. Palmer next visited the region surrounding San Luis Obispo, California, where he secured several new species, and thence he returned with Dr. Parry and Mrs. Parry to their home in Davenport, Iowa.

In December, 1876, he returned once more to the vicinity of St. George, Utah, this time for the purpose of making archeological explorations for the Peabody Museum of Harvard University. Accounts of the discovery of remarkable tablets bearing signs of the zodiac, conventional figures of the planets, etc., had been recently published, and

they were given serious consideration by many archeologists of good standing. Dr. Palmer's researches, however, proved that the remains of ancient occupation of the region were in no way distinguishable from those of similar character in Arizona and New Mexico. The plates were undoubted forgeries.

In addition to his archeological explorations he assisted Dr. Parry, who accompanied him, in completing a collection of the spring-flowering plants of the region.

It was now decided to invade Mexico in prosecution of botanical and ethnological work, and plans were formulated by which Dr. Palmer and Dr. Parry were to go together. The expenses were to be borne by several institutions as well as by individual botanists, who were to receive sets of plants. The two collectors accordingly proceeded to the city of San Luis Potosi, going by sea to Veracruz, and thence by rail to the City of Mexico. After visiting the National Museum in that city they turned northward, Dr. Palmer stopping on the way at the city of Zacatecas and at Aguascalientes.

After making extensive collections in the mountains of San Luis Potoso, Dr. Parry fell ill and was obliged to return home. Dr. Palmer continued the work, and after collecting on the tableland and mountains, returned by way of Tampico, descending into the more tropical lowlands near the gulf coast, and greatly supplementing the collections made in the higher altitudes.

Sets of plants were sent to the various subscribers to the expedition, but the most complete set was sent by Dr. Parry to the Kew Herbarium, which caused not a little dissatisfaction among some of the American subscribers. The results of the expedition were for the most part embodied in the great work by Hemsley, the "Botany of the Biologia Centrali-Americana."

The latter part of the following year, 1879, Dr. Palmer made extensive collections in western Texas, and in 1880 he returned to Mexico to supplement his previous collections, exploring chiefly certain localities in the states of Coahuila, Nuevo Leon and a part of San Luis Potosi. He sent a nearly complete set of the plants collected at this time to Kew, and they too were included by Hemsley in the "Biologia." A more complete set went to the herbarium at Cambridge, Mass., and were the basis of two papers published by Sereno Watson, in Volumes 17 and 18 of the *Proceedings of the American Academy,* in which a complete list of the plants collected by Parry and Palmer in 1878 and by Palmer in 1879 and 1880 was given.

The archeologists at Cambridge and in the Bureau of Ethnology becoming interested in the relationship between the aboriginal inhabitants of the tablelands of Mexico and of the great region of the Mississippi Valley, Dr. Palmer was engaged to make researches. Accordingly

from 1881 to 1884 he was almost continuously at work opening prehistoric mounds and graves in the states of Tennessee, Arkansas, Indiana, North Carolina, Georgia and Alabama.

In the latter part of 1885 he was sent to southern Florida to make a collection of corals, echinoderms, mollusca and other invertebrates for the approaching exposition at New Orleans. He gathered a wealth of valuable material, which, after the closing of the Exposition, became the property of the United States National Museum.

He was sent once more to the southwestern region of the United States, where he made a very complete collection of material illustrating the arts of the Cocopa, Pima and Yuma Indians. Much of his material was of an ethno-botanic nature, including a long list of food-plants, medicinal plants, fiber plants, etc., of the Indians, together with notes on the methods of cooking, brewing, extracting fibers, basket-making and the like.

Much pleased with Dr. Palmer's success, Professor Baird, director of the U. S. National Museum, decided to send him to the mountains of southwestern Chihuahua, a part of the western Sierra Madre of Mexico, for the purpose of studying the Tarahumara Indians of that region, an interesting tribe inhabiting caves and dwellings of the most primitive kinds; with the object of comparing them with the Cliff Dwellers of Arizona and New Mexico. Letters were sent to Governor Alexander R. Shepherd, then vice-president and general manager of the Silver Mining Company at Batopilas, informing him of Dr. Palmer's purposed visit, and asking such assistance as Governor Shepherd might be willing to give him in the prosecution of his work. Professor Baird's request met with a cordial and prompt response from Governor Shepherd, who did everything in his power to aid him.

Much botanical work was done in the immediate vicinity of Batopilas, especially at the Hacienda de San Miguel, situated at an altitude of 1,600 feet above the sea-level, the Hacienda San José, about twenty-five miles farther down the narrow gorge of the Rio Batopilas; at the Cumbre, or summit of the ridge above Batopilas, 8,850 feet above sea-level, where he found columbines, lupines, *Gaultheria,* gentians, alders, and *Ceanothus;* and at the Indian village of Norogachic, about 150 miles north of Batopilas, in the Sierra Madre, at an elevation of about 8,500 feet. This place is surrounded by mountain peaks more or less covered by junipers, madroños, manzanillas, pines and oaks, with a considerable snowfall during the winter months.

Among the plants collected in this region several proved to be new to science, and many were of economic importance. A list of them was published by Sereno Watson in the *Proceedings of the American Academy,* Vol. 21, 1886. The ethnological material was sent to the U. S. National Museum.

Among the plants used by the Tarahumara Indians was one of special interest, a small, turnip-shaped, spineless cactus called *Hikuli,* in quest of which they made long journeys to the mountains of eastern Chihuahua. It proved to be the narcotic "mezcal-button" (*Lophophora williamsii*), also known in Mexico by the name *Peyote,* or *Peyotl.* This plant causes delightful visions and strange hallucinations, and the Indians regard it with great veneration. Like their cousins, the Huicholes of the Nayarit Mountains of Jalisco, they observe certain rites or ceremonies in collecting it, bringing it home, and preparing it for use, which recall the superstitious practises of the *rhizotomi,* or root-gatherers, of ancient Greece.

Dr. Palmer's next expedition was to the state of Jalisco, where he made extensive collections, especially in the vicinity of Guadalajara. Not far from this city he descended into a wonderful barranca, or canyon, never before visited by a botanist. The account of his discoveries at this time recalls Schiede's description of his descent into the Barranca of Teocelo, near Jalapa, in the state of Veracruz.[6] His collection of this year included about 675 species, many of which proved to be new. A preliminary report of the botanical results was quickly prepared by Sereno Watson and published in the *Proceedings of the American Academy.*[7]

The following year he collected near Guaymas, the seaport of Sonora, on the island of San Pedro Martir, in the Gulf of California, and at Mulejé and Angeles Bay, on the gulf coast of Lower California. The results were also published by Watson in Vol. 24, *Proceedings of the American Academy,* 1889.

During June and July, 1888, he collected for the U. S. Department of Agriculture in the counties of Kern, Tulare and San Bernardino, California. A list of his collections at this time, published by Vasey and Rose, is the initial paper of the "Contributions from the U. S. National Herbarium," Vol. 1, 1890. The next year he returned to Lower California, collecting at San Quentin and Lagoon Head, on the Pacific coast, Cedros and San Benito Islands, and once more on the interesting island of Guadalupe, some distance off the coast. An account of the plants collected at San Quentin and a partial report of those collected at Lagoon Head were published in Vol. 11 of the *Proceedings of the U. S. National Museum,* 1889. An account of the remaining plants from Lagoon Head together with those collected on the coast islands above mentioned was published by the same authors in Vol. 1 of the "Contributions from the National Herbarium," to-

[6] "Botanische Berichte aus Mexico, mitgetheilt vom Dr. Schiede," *Linnæa,* Vol. 4, p. 233, 1829.

[7] "List of Plants collected by Dr. Edward Palmer in the State of Jalisco, Mexico, in 1886," *Proc. Am. Acad.,* Vol. 22, pp. 396–465, 1887.

gether with a short list of plants from Lerdo, in the state of Sonora, Mexico, at the head of the Gulf of California. At the latter place he collected great quantities of a parasitic fleshy plant, *Ammobroma sonoræ,* the "oyutch," or sand-food, of the Cocopa Indians.

In 1890 he spent three months in Lower California, collecting at La Paz, Santa Rosalia and Santa Agueda, as well as upon Raza Island and the island of San Pedro Martir, in the Gulf of California; and three months in southern Arizona, collecting at Camp Huachuca, Fort Apache, and Willow Springs. He also made two trips to Alamos in the mountains of southern Sonora, the first during the latter part of March and beginning of April, the second in the month of September. The results of these expeditions were published by Dr. Rose in the "Contributions from the U. S. National Herbarium, Vol. 1, pp. 91–128, 1891. In 1893 he collected in southern Idaho.

He afterwards collected in the more tropical regions of Sinaloa and Colima; at Acapulco, the seaport of Guerrero, from which the galleons of the ancient conquistadores sailed to the Philippines; and in the Territory of Tepic. Several times he has revisited the interior states of Coahuila and San Luis Potosí, collecting among the pines and oaks of the mountains, as well as on the arid plateau and in the warm moist region of the lower land near the Gulf of Mexico. He has penetrated into the heart of Durango, making two trips to the Sierra Madre of that state, once in 1896 and again ten years later, in each case going as far as the newly built railroads would take him and making extensive and often painful journeys to lumber camps and mining regions in the mountains. In 1907 he revisited Tamaulipas, collecting especially near Victoria and Gomes Farias. In 1908 he revisited Chihuahua, this time collecting near the capital and at the neighboring stations of Santa Eulalia and Santa Rosalia.

His last trip, in 1910, was to the gulf coast, in the vicinity of Tampico, Tamaulipas.

From all of these expeditions he returned laden with a wealth of material, his specimens remarkable among those of all collectors, not for their prettiness, though they were often beautiful, but for their completeness, showing when possible bark, root, wood and seed-pods or fruit, as well as leaves and flowers. He did not content himself with a single example, but in spite of difficulties would often bring a whole series, to illustrate vegetative foliage and branches as well as flowering branches, knowing that the aspect of the foliage might vary on different parts of the same plant, and that entire plants might differ according to their situation. He accompanied the specimens by accurate notes as to locality, habitat and season, not disdaining to give local names however barbarous they might sound to ears tolerant only of classic Greek and Latin; and he noted the taste and odor of bark and wood and leaves

as well as the color of flowers and the uses of fruits, seeds, herbs and roots, together with the virtues attributed to them by the simple natives, no matter how foolish such information might appear to the eyes of the learned.

And now, as his busy life is nearing its close, enfeebled by hardships and almost incessant physical suffering, he sits close to the fire with his great coat around him. His last set of plants has been disposed of. Is his task finished? He can not bear to think so. He had planned to do so much more. As he closes his eyes he has visions of palm trees reflecting their crests in the still lagoon; or perhaps he hears the tinkling of bells as flocks of goats wander across the sunny plain and climb rocky hillsides dotted with cactus, maguey and yuccas; or perhaps he is once more among pines and oaks on a mountain top, or in moist forests gathering orchids and creeping arums. His old enthusiasm comes back; his pulse throbs with renewed vigor. No, the end is not yet. Once more he prepares his pack; his staff stands in the corner. He unfolds the map. To-morrow he will start off, but to what fresh field he can not yet decide.

It has been impossible within the limits of this paper to do more than enumerate many of the localities explored by Dr. Palmer. To give a detailed account of his work would fill hundreds of pages. Every student of North American botany can bear witness to its value. We have already heard the testimony of the distinguished botanists, Professor Gray and Dr. Torrey, given in the early part of his career. He has added hundreds of species to science and many more of his collecting remain to be described. Scarcely a monograph of a family or genus appears, including representatives in Mexico and the southwestern United States, but among the species described are new ones based upon types collected by Edward Palmer. My list thus far reaches 1,162 new species of flowering plants discovered by him, but I am sure that this does not include all. The composites lead with 259 species. It is not possible to tell definitely how many well-established species bear his name. I have counted 200. It is pleasant to think they will continue to bear his name for centuries to come, eternal witnesses to his wonderful activity, forming a monument more lasting than sculptured marble, recording the services he has rendered to science and his fellow men. And in all the years to come no history of American botany will be complete without an account of the work of Edward Palmer.

# FREUD'S THEORIES OF THE UNCONSCIOUS

By Professor H. W. CHASE
UNIVERSITY OF NORTH CAROLINA

ONCE upon a time it was the fashion to demonstrate witchcraft by sticking pins into the unlucky suspect. If any spots were found that appeared insensitive to pain, the unfortunate was forthwith declared a witch, with dire consequences to herself. Now-a-days such anesthesias are recognized, not as signs of a compact with the devil, but as symptoms of that mysterious disease of personality, hysteria.

This reversal of the point of view is typical. We have come to look upon many phenomena that were formerly ascribed to supernatural agencies—crystal gazing, second sight, hallucinations, double personality, possessions, ghosts, even mediumship—not as manifestations of supernatural powers, but as due to an abnormal condition of mind in the subject. In less enlightened days the Miss Beauchamp of whom Prince tells us in his "Dissociation of a Personality," who was several personalities by turns and had, as a rule, as one personality no recollection of the acts she performed as another, might have been burned as a witch. To-day she is a problem for the psychologist.

As knowledge of the psychological nature of such abnormal phenomena has grown, the need has increasingly been felt for some comprehensive explanation of their character. Here, for example, we have a girl (in a case reported by Janet) who has nursed her mother through a painful illness from consumption, resulting in death. The poverty of the family would not allow her even proper nourishment for her suffering mother. Her grief and despair may be imagined. But after the funeral she has apparently forgotten the whole series of events; the entire "complex" has dropped from consciousness. She is bewildered by any mention of the circumstances. But, on occasion, she falls into a trance-like state, in which she rehearses the circumstances of the illness and death of her mother with the utmost fidelity. And then, suddenly, she is normal again, but again she has no recollection of the crisis through which she has just passed. Here is a series of events apparently split off from her conscious personality altogether, yet instinct with energy that at time brings it to the surface. Here is another hysterical patient who has forgotten all about the shock that the physician suspects must have occurred as the starting point of her disdisease, and yet in hypnosis the whole thing comes out as vividly as ever. Consciously it could not be recalled, and yet it was existing and

working; for it is a peculiarity of such split-off complexes that they may cause all sorts of conscious disturbances, though the patient himself has forgotten all about the event which started the disturbances, or sees no connection between it and the disturbances which it has set up. Here, for instance, is a young German girl (the classic case of Anna O. reported by Breuer and Freud), well educated, knowing some English, yet not using it as fluently as German. At a certain period in her life she suddenly becomes unable to speak or read her mother-tongue, and is obliged to use English altogether. Finally, in a hypnoidal state, she remembers that, once while she was watching by the bedside of her father, she was frightened by a sudden hallucination. Terrified, she tried to pray, but all that came into her mind were the words of an old English nursery rhyme. The shock, and her manner of reaction to it, caused her to forget her German, and to retain only the English, which had come to her aid at this critical period. There was no connection in her mind between the shock and the disturbances which it had left behind, yet the association, though not a conscious one, had been set up somewhere, somehow.

But all this is abnormal. We do not have to go so far afield to see instances of the same mysterious workings. Who of us has not had the experience of giving up a knotty point in despair for the time, to come back to it and find that our ideas had somehow fallen into place, had apparently worked themselves over without our help. Or how often a name that we have tried unsuccessfully to recall pops into our mind in the midst of some other train of thought. In such cases we have not been dealing with conscious activities as we know them. What has been the process? What has been going on?

It is such considerations as these that have led to the building up of theories of unconscious action, which fill out the gaps in our conscious life. By unconscious action we understand action which goes on without our being aware of it, and yet which seems intelligent, adapted to a purpose. In short, it is activity which it is hard to differentiate from conscious action, except in its lack of this very property of awareness. Most psychologists to-day admit that activities which are more or less like conscious activities go on under the threshold of consciousness; but the orthodox psychological explanation is that they are mere physiological activities, complex changes in the neurones, and that there is nothing mental about them. The brain itself is so complex, they say, that there is no need of supposing that we really think and feel unconsciously, all that occurs is a change in physiological arrangement. The mental and the conscious are co-extensive terms. On the other hand, those who have dealt most with the abnormal phenomena, and are less at home in the field of pure psychology, see in such conscious activities something mental as well. The phenomena are so

complex, they say, that if they occurred in an animal, for example, we would unhesitatingly call them mental. They are of course physiological, but it is hard to explain their apparent intelligence without supposing that they are mental as well. The conflict is very like that now waging between the two schools of animal psychologists, those who would reduce everything in the life of the animal to a series of mechanical reflexes, and those who look for signs of conscious intelligence. Like this conflict, too, it is one which can never be decided by introspection, it is only as results accumulate that the balance will swing to one side or the other. In accordance with the law of economy that regulates scientific thinking, it would seem that such activities ought to be explained in physiological terms if it is possible to do so; in this case the question becomes: are they too complex to be so explained?

The thing of all others most needful here, then, would seem to be more evidence as to the nature of such unconscious activities. Such a body of evidence has been brought forward by Professor Freud, of Vienna, whose work is just beginning to be known in this country. Professor Freud is primarily an alienist, a former student of Charcot at the Salpétrière. In the course of a long practise with neurotic patients, he has arrived gradually at theories of the mechanism of the unconscious, which, if they are substantiated, will go far to revolutionize present psychological conceptions.

Freud's theory is unique in that he supposes the region of the unconscious to be built up of two distinct layers, and that he would explain all the facts of unconscious action as due to the interaction of these two layers.

The upper layer is a sort of vestibule to consciousness. When, for example, as in the case cited above, we try in vain to recall a name, and later find it coming of itself into consciousness, Freud would explain the case as follows: The train of conscious activity set up by the effort has, as soon as attention was turned away from it, sunk below the threshold of consciousness. But it does not at once die away. The activity rather goes on exactly as though it were in consciousness, new associative connections are made, and by and by the associative train succeeds in reaching the name of which we were in search. This now appears in consciousness, seemingly out of all associative connection, and yet a train of association has led to its discovery, only it was a train of unconscious association. So during the day we break off scores of trains of thought without carrying them to a conclusion, because they are too trivial, too complex, too unwelcome, to occupy the mind further. Such trains of thought drop below the threshold, and there may form new associative connections. If these are strong enough, they may again appear above the threshold, apparently without cause. If such connections are not formed readily, the activity may die out without

effect. Or such a train of thought may form still other associations, and sink to lower depths of the soul, still to be considered. This upper layer of the unconscious, then, which we find in Freud's theory, is very like the usual sense in which the word "unconscious" is used, especially by those who would see something mental in its activities.

But the unique contribution which Freud has made to the subject is in his theory of the lower layer of the unconscious, which is in many respects totally different in its structure and activities from the upper layer which we have been considering. In order to see his conception more clearly, let us follow for a moment the development of the individual. We all know that the child exhibits many tendencies which in the adult would be signs of criminality, insanity or abnormality. Our conscious personality as it exists to-day is the result of a long process of growth, each stage built on the ruins of the one beneath. The child is savage, primitive; it is only by degrees that he becomes adapted to the restraints of our modern civilization, and represses his old activities. But now, says Freud, such repressed activities leave their traces behind. They may not seem to affect us consciously; we may have even forgotten many of the old ways of thinking and acting, but their traces still exist. What has become of the energy which went to the gratification of our old selfish, individual, feral, modes of thought and action? With most of us the energy has found for the most part new outlets, it has produced the motive force for new developments. It has been "sublimated" to higher uses. But the draining off of the energy from the old modes of action has not been complete. The old primitive tendencies still persist unconsciously in the best of us, and will crop out in some form or other if the provocation be sufficient. We have repressed our childish desires so long that we may have forgotten that they ever existed, but yet they are not quite dead. Particularly is this true in the realm of sex—for Freud holds that the child has a sex life of his own as truly as the adult. It has, to be sure, not yet come to a head in the sexual organs, but it is none the less existent, and in ways which in the adult would be called perversions; which, indeed, if not repressed, are the origin of perversions in later life. Now these old ways of sexual satisfaction are usually repressed under the influence of the environment, yet the tendency to their gratification still exists; we may see it cropping out in the most normal of us in dreams, for example. The energy that went to the satisfaction of such impulses has for the most part been drained off into new channels, but a little of it still remains locked up with the old complexes. Perhaps none of us have as much energy at our disposal for mental work as we ought to have, for some of it still is attached to old and outworn tendencies, making it a little easier and a little more possible for them to come into operation under favoring circumstances than for new tendencies so to do.

Now, for Freud, it is of just such cast off complexes, each with its own complement of energy, that the lowest level of the unconscious is made up. All the unethical acts and unsocial ways of thought of the child, repugnant to us to-day, still exist in the lowest dark chamber of the soul, not strong enough to break out into action, but alive. It is the penalty which we pay for our civilization, that it imposes standards of thought and action which are foreign to the deepest tendencies in us, modes of life of the cave-man and the ages before civilization, which have left their marks on the soul forever. And for all of us there has been some strain in adjusting to its requirements, resulting in the abandonment after a struggle of the old racial ways, and the substitution of newer and more ethical modes of action. But a part of our personality still remains in the troglodytic stage. We may not allow this part expression; we may not even be conscious that it longer exists, and yet it lives and works below the threshold, just as the remembrance of the death of her mother still affected the girl, though consciously it had lapsed. With the split between childhood and adolescence, the chasm between the old and the new becomes still wider; we turn our back more and more on the old ways; they lapse from consciousness more and more completely. Childhood seems a little alien to all of us; there has been a "transvaluation of all values" so that the remembrance of how we thought and felt then comes to us with the mark of a little strangeness upon it. It is strange just because we have cast it all out, we have "put away childish things." But in the dark limbo of the unconscious they still live on, unconscious though we may be that such is the case. The lowest level of the unconscious is thus far removed from consciousness in its modes of functioning. The conception that such tendencies still function, still need continual, though not conscious repression, is the essential point here.

But now what is the mechanism that prevents us from knowing that these old tendencies are still striving upward toward conscious expression? Consciousness is guarded from a knowledge of their existence and their activities, holds Freud, by the interposition of the upper level of the unconscious. This acts like a censor, a guard at the gate, and will not admit to conscious expression these outworn complexes, because of the pain which they would cause us if we were compelled to take account of them in our thinking. It would require too much energy consciously to keep them down; so it is the function of the upper level of the unconscious to save consciousness all this trouble, and to leave it free for other things. This it does, in ordinary circumstances, so well that we are not even aware that any repression is going on, or, indeed, that there is anything to repress. We have repressed our old complexes so long and so well that the act of repression has dropped below the conscious level; we are not aware of its existence. But, on

the other hand, it is continually going on, for the old complexes are always striving up to expression. And so the system of energy in the unconscious is a two-way system; the upper system keeping down the lower. If this be true, how different is our mind from the report which consciousness gives us. Outwardly, all is calm and placid, and yet beneath the surface is the mighty conflict always going on. We are like citizens sleeping in security while outside the gates the battle rages hot between our protectors and our enemies. Fortunately, it is our protectors who are usually victorious; the repressive force of the upper level is strong enough to prevent the emergence of the denizens of the lower stages. But this is not always so. Occasionally the assailants find a breach in the fortifications, or a weak spot in the line of battle, and echoes of the conflict come to us within.

To abandon figures, the lower level of the unconscious may under certain circumstances win a partial victory, and some feature of the old complex may arise in our minds. This may happen in the following way. Suppose that a train of thought broken off during the day, and sinking to the upper level of the unconscious, works out there to a conclusion which permits it to be brought into associative connection with one of the complexes on the lower level. The whole process has been unconscious; we are not aware that such a connection has been made, and yet in the trivial event of the day there has been some element, some common feeling tone, some phrase, some suggestion, which is like enough to the old complex to form an associative connection with it. Suppose that during the day we express some slight concern about the health of a near relative, and, in the pressure of work, forget about the matter. Under the threshold, on the upper level, this train of thought may spread further. Now it is one of the traits of children that they have at first little sympathy and love for their younger brothers and sisters. It is not uncommon for them to express a wish that they would die, that they might have more attention from their parents. For death for the child means of course only an absence; he has no conception of its real significance. But such an idea is foreign to the adult mind; it has been so repressed and was expressed at so early a stage that we can hardly realize that it ever existed. However, on Freud's theory, it still does exist, and is continually being repressed by the upper levels. Suppose now that the train of thought having to do with the health of the relative in question works out to a conclusion below the threshold which tends to call up the old complex. This is at once given new energy, its repression is more difficult. And yet it does not emerge consciously. But at night, when the inhibitions are down in sleep, when the repressive force is not quite so great, it makes a supreme effort, and gets through—in a dream. We may awaken terrified from a dream of the death of the same relative who caused us the

concern during the day; what gave the motive force to the dream was the old childhood complex, which in this case has, by the help of the new energy, succeeded in breaking through into consciousness. For Freud, the motive force behind a dream is always that of some old complex in the depths of the soul; the dream is a deeply significant revelation of the true nature of our unconscious life, to him who knows how to read it.

This last qualification is important, for it usually happens that the inhibiting force, though not able to completely prevent the emergence of the buried complex, distorts it almost beyond recognition, so that the dream seems to us absurd, disconnected, void of all meaning. This distortion is sometimes so complete that there is only here and there a hint of the true meaning of the dream; it seems to be made up from trivial events of the day alone; but in such cases close examination will show that rational association of such events has been carried on through the complex, which has served as the connecting link and given new energy which permits the trivial events to recur in the dream, though openly the complex does not appear at all. Such was the dream of the woman who saw her nephew lying dead, and yet felt no grief. Now it chanced that on the day before, she had bought a ticket to see her lover, from whom she had parted, in a public performance, and was looking forward eagerly to the event. Some of the details of the dream seemed to suggest that there was some association with this fact; and, indeed, it was found on analysis that the last time she had seen her lover was at the funeral of another nephew. It was as though she had said to herself, "If my other nephew dies, I shall see him again." Do we not perhaps see here the activity of the old childish way of thinking that would sacrifice anything for a moment's happiness for the individual? And yet that complex had not appeared at all in the dream as such. It is thus Freud's thesis that the dream never says what it means, that it is the product of a compromise between the two systems of energy. The complex is distorted in getting around the censor, and thus there arise all sorts of symbolic and indirect ways of expression; the complex is only alluded to in the dream in allegorical ways, or under cover of the trivial events of the day that stand in connection with it; it is not expressed directly. Blood and fire in dreams may appear as sexual symbols; the symbolism may be very complex, as in the case of some of the symbols of primitive man; associations may be determined in the most superficial ways; for example, one person may stand for another in a dream on no more basis of identification than that both wear eyeglasses. The complex makes use of any possible associative connections in order to utilize a little energy to strengthen itself. And it is of course also true that the more indirect and symbolic the associations, the less likely we are to suspect the complexes which are manifesting themselves through them, and so much

the more likely will the complex be to avoid the censor. It is as though the complex, in its mad desire to escape, disguised itself and slipped around the back way. It succeeds in escaping, but its disguise alters it so beyond recognition that even its best friends will not recognize it.

Thus in the dream we see the conflict of the two systems of energy, and, if we are skilled, we may even interpret the signs as the woodsman would do, and tell what complex has passed that way, and how it was clad. For the first time the psychology of dreams is thus given a coherent setting, which shows it as a type of activity not foreign to our usual modes of thought, but of one piece with them. For the dream is only one illustration of this conflict. What, says Freud, are the symbols of the artist and the poet but just such disguises, the product of the conflict in his own soul between the primitive and the civilized ways of thought? Other observers have already shown that the root of art is in sex; here we see that it is through the symbolism of a sex-conflict that it develops.

Now, suppose that the complexes are a little stronger, have not been as well suppressed as in the normal individual; in such a case they may break out as hysterical symptoms or obsessions—yet the emergence is not complete, though more complete than in the dream, for the individual still has gaps in his conscious memory with regard to the ways in which the complexes are connected with his symptoms, or he may have forgotten the origin of some of his symptoms altogether. And yet in every case his neurosis goes back and roots in the strength of just such complexes, which have seized on events of his adult life somewhat similar to them in nature, and through the breaches thus made have burst forth into a real, if detached, life.

Shocks, traumatic experiences, cause forgetfulness and splitting of personality, on this theory, because they resemble sufficiently in some respect the old childhood complexes, and these latter are for one reason or another so strong that the experience forms its associative connections with the older complexes, and not with conscious personality. So it drops below the level of consciousness, to in turn strive to rise to the surface. The hysterical symptom is then a symbol of the conflict between the two tendencies. If there were no conflict the old complex would emerge wholly; that it emerges in indirect and symbolic ways is additional proof of the conflict which is going on. One must, then, have reached a certain stage of ethical development, must have repressed old tendencies, in order to develop a neurosis.

It is of course true that this repression of the lower by the upper is in general good for the organism; it is well that consciousness should be left free. The fact that it miscarries at times and a neurosis or a nightmare ensues is only because of the relative strength of the complexes, and not because of a defect inherent in the system itself.

Thus for Freud the most real part of the drama of the soul goes on

behind the scenes. Most things that we think we do from conscious motives, most of the thoughts that come into our minds, are but the surrogates and the symbols for the processes that go on beneath the threshold. Ideas are so censored before they get admission to consciousness that we have often little notion of their real nature, and can only wonder that the apparently meaningless idea should haunt us so.

If these conclusions are substantiated, we seem to have a new light shed on the old question of the unconscious. It becomes for us the most real part of ourselves; the expression of our deepest tendencies. It is a realm far larger and far deeper than consciousness; it holds secrets that we thought lost forever. The psychologist would explain the unconscious from the nature of consciousness; Freud, on the other hand, explains consciousness from the nature and function of the unconscious.

The assertion that much of our thinking is symbolic in its nature, due to the fact that it serves as a sort of safety-valve for the escape of our repressed complexes, is of course a problem which can never be solved by appeal to consciousness alone. And it is so with most of the other positions which Freud has taken; we are following pathways where introspection is no guide. Thus he would have us shift the emphasis in psychology from a study of consciousness over to a study of the unconscious. Consciousness, for him, is but the surface; it is in the depths below consciousnes that true reality is found.

We may then sum up the contribution which Freud has made to the psychology of the unconscious as follows: he has supposed that the unconscious consists of two streams of tendencies, or energy, one stream striving to revive all the time experiences which would be repugnant to us, and which we have outgrown, and the other striving to check the revival of such tendencies. As a result of this conflict, we have introduced into our thoughts and acts, especially in conditions when barriers are somewhat down (as in dreams, lapses, neuroses, reveries), a vast deal of the symbolic and the indirect methods of presentation.

Now is such activity as we have been considering mental in its nature—are the unconscious associations and connections of which we have been speaking really associations and thoughts that go on underneath the surface? Or are we dealing with a very complex degree of nervous activity, and with that alone? Freud nowhere states his own position definitely, though it is perhaps too easy to accuse him of leanings toward the mental interpretation. What he has done is rather to open up new lines of approach to the problem, to give us a consistent and closely reasoned interpretation of observed facts. Psychologists are beginning to recognize that, right or wrong, he must be reckoned with. He has given a stimulus to work along this line that may go a long way toward the ultimate solution of some of our baffling psychological problems.

# IMPRESSIONS OF MILITARY LIFE IN FRANCE[1]

By Professor ALBERT LEON GUÉRARD

STANFORD UNIVERSITY

I SERVED 309 days—we counted them from the very first, and shouted every morning "Encore tànt et la fuite!"—as second-class private in the 129th regiment of the line, stationed at Le Havre. I was paid one cent a day, and in addition was entitled, every ten days, to a packet of tobacco at half its market value. That was in 1903–04, under the old (1889) law. University students, teachers, artists, artisans and craftsmen (ouvriers d'art), ministers and men having a family to support (soutiens de famille) had to serve, nominally one year, practically ten months. The rest—two thirds of the contingent—served three years. Any one mentally or bodily deficient was totally exempted. At present, the universal term of service is two years, without exception. Many of the halt and maimed, formerly totally excused, are employed in office work or in the repair shops, which offer a sorry sight. Candidates for the priesthood were for a while placed in the regular troops. Now they serve in the ambulance corps, as do a few determined Tolstoians who stubbornly refused to touch a weapon.

My impressions of the army were unfavorably colored, for several reasons, and my testimony is open to discount. First of all, I was a widow's only son, and was brought up very strictly by my mother. Then, the Dreyfus case was hardly over at that time (it was before the second "revision," and the final triumph of justice), and for the last four or five years I had been an enthusiastic Dreyfusist and attended numberless antimilitarist meetings. I found myself among workmen from the mills of Elbeuf and Rouen. Normandy is a fine country, and the race that lives there still offers splendid specimens. But it is rapidly being ruined by an evil greater than militarism—alcoholism; alcoholism to a degree which I as a Parisian did not dream of. Children seemed to be brought up on "Calvados" (cider brandy). The result can be imagined.

Finally I was stationed at Le Havre, the second seaport in France. The barracks rose right on the quays, and I could see in all its hideousness the gross immorality which prevails in all shipping centers. On the very first day, our sergeant carefully explained to us when to go to

[1] This article is an extract from a private letter in answer to a query concerning the military system of France. It is published by permission of Professor Guérard.—David Starr Jordan.

the brothels (on the day of sanitary inspection), and how to tell a diseased woman. I received a shock which I remember clearly to this day. Yet the fault lay not with militarism, but with social conditions. These being granted, our sergeant's eloquence was to the point;[2] and there was some advantage in my being compelled to realize "how the other half live."

All educated conscripts, serving one year, were segregated, and had to study for becoming reserve officers. I wanted most particularly at that time not to become an officer, even in the reserve. So I did not go in with the special company of "dispensés," but remained with the "skimmed milk." The social and intellectual level among the dispensés must have been much higher. I am not so positive about the moral level. They were kept more busy, had more intelligent work to do, and their instructors—officers and non-coms—were picked men. But I had the advantage of seeing more of the real thing. I did not suffer in the least from my position. The fact that I was the only educated conscript left in the company (I was then twenty-three, had spent two years in England, and held a few degrees) was a great advantage. I was made instructor of the illiterate—three half-witted peasants, two of whom did not even know that France was a republic. I gathered a library of 600 volumes for the use of the soldiers. I coached my sergeant major for an examination. Thus I had congenial work instead of the usual fatigue duties (cleaning the room, etc.), and after a few weeks of gradual adaptation I had a fairly pleasant time of it.

From the material standpoint, life in the army is on a higher level than the lowest among the poor (leaving out the destitute), although not quite up to the average. My terms of comparison are the London slums, on the one hand (I spent a year at Toynbee Hall in Whitechapel), and on the other hand, the conditions which prevail among ordinary working people—my neighbors and acquaintances—in Paris. Food is coarse and monotonous (boiled beef every morning), prepared in bulk by unskilled cooks, but it is abundant, and cleaner than the fare afforded by cheap restaurants. I tried the canteens, the non-coms' mess (by special privilege) and the popular eating-houses near the barracks, and went back in disgust to the plain, wholesome regimental beef. Cleanliness is enforced in an unpleasant, rough, but efficient way; hair cropt short, frequent hot shower baths (thirty in a room at times!), sea-bathing in the spring, on a beach of brick bats and tin cans; walls kept whitewashed and coal-tarred; lavatories disgustingly primitive, but disinfected every day. Our captain "took pride" in the feet of his

[2] Our sergeant was unwittingly following in the footsteps of Field Marshal Lord Roberts. Cf. Lord Roberts's famous circular-memorandum 21 and W. J. Corbet's comments thereon in "Bella! Bella! Horrida Bella!", *Westminster Review*, March, 1902.

company, and inspected them repeatedly. The amount of work was not excessive for any but weaklings—soon weeded out and put to sedentary work; it was generally hard and prolonged enough to prevent habits of laziness from being formed. On the whole, a very unpleasant experience for any person of fastidious tastes and habits; tolerable for healthy individuals of an adaptable type; satisfactory for the great majority.

From the moral point of view, the question is more complex. I no longer hold, as I did in the fever of my Dreyfusism, that the army is the school of all the vices. Such exaggerated statements would harm the best cause. The indictment may have been true of the old professional army, recruited exclusively from the lowest strata, and entirely separated from the rest of the nation. Yet I have known veterans of the second empire who were simple-minded, honest, kindly, delightful old fellows. A regiment is not much worse than a big factory. Factory life in Europe is bad enough; military service extends its evils to agricultural laborers, and also to men who would otherwise have escaped these lowering influences. As for traces of moral uplift in the army, I have totally failed to notice any. War may be a stern school of virtue: barrack life is not. Honor, duty, patriotism are feelings instilled at school; they do not develop, but often deteriorate, during the term of compulsory service. Daily drudgery deadens enthusiasm. That is probably why so many French "Nationalistes" tried to dodge the law and shirk their military duty, in order to retain their patriotic feelings intact.

The first evil of military life is that young men are transplanted away from home, and no provision made for sane, wholesome entertainment. Military clubs have greatly developed of late. They are still too few, and so "philanthropic" in character as to frighten most men away. A soldier is free every evening after five. This would be dangerous for most young workmen, who do not know what to do with their leisure hours. The absence of any home circle makes it much worse. For a long time the principle was to send young recruits as far as possible from their place of residence. The idea was to break down local differences, to prevent the army from siding with the population in case of political or social conflict (the brief mutiny of a southern regiment at the time of the wine-growers' riots in 1907 shows that this is a real danger), and to foster the old spirit of exclusive loyalty to the flag. Now, the contrary principle of local (regional) recruiting has been adopted, with a view to more rapid "mobilization," and also under the pressure of public opinion. Even then, it was impossible for most soldiers to go home oftener than once a month. Uneducated young men, friendless and idle, turned loose in the evening in a big city, could do little good. There were certainly temptations to drunkenness and debauchery greater than those which would assail the regular working man. And unfortunately the repressive measures were a farce. The non-

commissioned officers, so strict about trifles, sympathized with the drunkards and shielded them, and the penalties were so severe that the officers themselves often preferred to close their eyes. The old ideal of the eighteenth century soldier, "le vin, l'amour et le tabac," remains unchanged to this day. Home-sickness, chiefly among peasants, the squalor and monotony of barrack life among clerks and even students, often lead to a sort of dull despair, which seeks relief in drink (sometimes in suicide, too—there are occasional epidemics). On the evening of July 14 there were hardly half a dozen men sober in the whole company of a hundred.

The officers had no moralizing influence. The superior officers were seldom seen and greatly feared. The subalterns (captains and lieutenants) belonged to three groups: (1) A few clever, ambitious young men. These, all too rare anyway, scorned the routine of barrack life. They spent little time with the men; they studied, or managed to be sent abroad or in the colonies on a mission, or served at headquarters and on the general staff. (2) A large group of young men of means and leisure, not a few belonging to the old nobility. They serve because it is a family tradition, because a man must do something, because of the social prestige of the uniform—not seldom with a view to the larger price which officers command in the matrimonial market in the form of a dowry. They are, on the whole, amiable, inefficient and totally without prestige with their men. The old military caste, still the backbone of the German army, is merely an uninteresting survival in France. Distrusted by the government on account of their royalist opinions, without hope or desire of reaching the highest positions, they give a contagious example of indifference and idleness. (3) Men risen from the ranks—efficient drill-masters as a rule; not seldom kind with their men in a rough way; but often coarse, uncultured, intellectually paralyzed by twenty years of garrison life. The pay is small, the standard of living set by the officers of the second group is high; plebeian or free-thinking intruders are mercilessly snubbed. Silent or open rivalry of aristocrats and commoners, of school-trained and unschooled officers; a general spirit of uneasiness, listlessness and ennui; the most blindly patriotic men not in sympathy with modern France; with all these causes of division, officers as a body can have no real influence on their troops.

As for the non-commissioned officers, I think that Lucien Descaves's sordid and disgusting book, "Sous-Offs," does not slander them. The pay is exceedingly small (from twelve to thirty cents a day), the prospects of promotion not very bright, the work not attractive to a normal, self-respecting man. Only actual failures, or men who shrink from responsibilities in civil life, will take up military service (in subordinate ranks) as a profession. Working men despise them exactly as they despise flunkeys—and they have all the vices of flunkeys—laziness, arrogance and

servility. They are undoubtedly inferior to the average foreman or head clerk. In the army authority is much more absolute, obedience more strictly enforced than in civil life. An act of disobedience, "talking back," means not "the sack," but imprisonment, the court martial, the disciplinary companies of Africa or even death. Yet in civil life authority generally implies some degree of real superiority; in the army it is often vested in men flagrantly inferior to the average. Hence a spirit of sullen opposition among the soldiers. The only enduring bitterness which my passage in the army left me was due to the pettiness and tyranny of these underlings. Yet I found among them one unusually able and well-meaning young man, a sergeant-major who died three years later as a lieutenant.

The most demoralizing features in French military life are due to an incontestable progress in the French mind—its gradual loss of faith and interest in military glory. Henceforth the army is considered as useless, dangerous, a burden without a compensation. Authors of school books may be censured for daring to print such opinions, but the great majority of the French hold them in their hearts. Nay, there is a prevailing suspicion among workingmen that the military establishment is kept up for the sole benefit of the capitalists, and the reckless use of troops in case of labor conflicts gives color to the contention. In missions, explorations, aviation, rescue work and on colonial battlefields, the French have shown the same enthusiastic spirit as of yore. But dreary barrack life, without a clear purpose, without an ideal, is more than they can bear. Hence, a universal spirit of indifference and laziness; the main point is to reach the end of the year without trouble, and with the least possible effort (vulgo "tirer au flanc"). Those who succeed in shirking duty are admired and envied as "debrouillards." A disease or an accident, if not too painful, is considered as a stroke of luck; it gives a soldier a few days of far-niente. The military doctors have to exercise the closest scrutiny on malingerers and shammers. To waste time and to escape punishment are the only ideals. There is no incentive to good work. In this respect military life is vastly inferior to industrial life. Men who serve only two years do not aspire to promotion; by working hard for fifteen months, they could barely manage to become sergeants for the remaining four or five. They can't be turned out for inefficient work. I believe the barracks were the school in which the French working-men, naturally industrious and conscientious, learned the terrible habit of "Sabotage." No legitimate superiority is recognized in any way. Education, refinement, cleanliness—verbal, physical and moral—are causes of suspicion. Brute strength, profanity, capacity for strong drink, are titles to respect. Many a workman's son, trained in technical schools, aspiring to better manners and a higher ideal than those of his first associates, is during his stay in the army dragged down back to his old level.

So my general impression is that the army has on the whole no uplifting influence whatever; and without being so black as it was sometimes painted, it has a lowering effect on all except the very lowest. I must, however, mention a few hopeful signs of transformation, which seem to point to a compromise between the army and modern democracy.

The first is the absolute equalization of the term of service. Before 1905 the wealthy classes had either escaped service altogether (paying a substitute, or buying themselves off directly) or served one year in special corps while the rest served five or three. They consistently opposed the general adoption of the one-year term of service, which they themselves enjoyed. Now, it will be easier to further reduce the term of service, first to one year, then to six months. With such reduction the dangers of military life decrease (less idleness, more interest), while its good features (as a school of citizenship and physical culture) are retained.

2. For the last ten years an immense effort has been made for transforming the army into a great educational agency. *Le Temps,* always opposed to any form of progress, recently published a skit in which civil professors in the army (professors of civics, hygiene, geography, rural economy, "prévoyance," etc.) complained that drills, marches and manœuvres were interfering with their teaching. Nay, pacifist lectures were at one time regularly given in French barracks (under General André). Of course it would be more sensible to spend the money directly on education. But the gradual "humanization" of the army is an excellent thing.

3. At the time of the postal strikes, of the railroad strikes, of the Seine flood, the army was called upon to fulfil various duties, and did it admirably. There is a great danger in turning the army into a universal strike-breaking corps, or a body of "compulsory scabs." On the other hand, this industrial use of the army points to a mighty transformation; the war forces could become, as W. James intimated, reserve forces of peace, for great public works, sudden emergencies, national disasters. (Herein again the wit of journalists found a free field; it was announced that nursery-maids had formed a union (syndicat) and struck for shorter hours. The Nth regiment of engineers was detailed to take their places, to the great delight of cooks.)

We must look forward to a gradual transformation, for militarism will not be rooted out in one day. Costly as it is, the nations grow rich in spite of the burden. There is no doubt but France is amassing wealth at a rapid rate, and fast becoming the banker of the world, while Germany's progress is stupendous. France's toll on the foreigner (investments abroad, and expenses of tourists) alone more than pays for the interest of the debt, and the cost of the military establishment. Conservative papers, like *Le Figaro* and *Le Temps* sound notes of warn-

ing when new educational or social laws are proposed; but when a reduction of military expenditure is mooted, they prove conclusively that the country is marvelously prosperous, and could afford a few more army corps and a dozen super-Dreadnoughts.

Beside the spirit of mutual diffidence which centuries of hostility have fostered, and which the recent attitude of Germany has revived, the strong point of militarism remains its sentimental appeal. Dreary barrack life is still linked in popular imagination with the sombre but grandiose epic of ancient wars. Men serve their time when they are young and buoyant, when no hardship is unendurable, when even the memories of unnecessary fatigue, squalor, petty tyranny, are transfigured by the general glow of youth and hope. I for instance look back upon these days of servitude with a sort of pleasure. I remember the fun, the marching at the sound of bugles and band, or singing away on the highroad; the mock guerilla warfare around Norman farms in the early morning; the incontestable grandeur of a division in battle array. Soldiering is a pretty game, although murdering is an ugly business. It is possible that wars will be abolished generations before armies are suppressed.

# REALITY AND TRUTH

By Professor T. D. A. COCKERELL
UNIVERSITY OF COLORADO

REALITY may be conceived of as having three aspects, the knowable or scientific, the imaginable or metaphysic, and the unimaginable or metapsychic. These three elements of being are not in themselves distinct, but depend for their separation on the condition of the perceiving mind. They are so closely interwoven that every part of reality may be said to contain them all; every circle of thought being partly distinct, partly faint, partly broken.

The discussion of the metapsychic appears at first sight to be impossible. Since it is postulated that the content can not be material for thought, how can it be discussed? No creature, indeed, can contemplate its own metapsychic field, but it may contemplate that of others. Our best established science is metapsychic for many animals higher in the scale than the jelly fish. Were man the only living being, he might still afford variation enough for the study of metapsychics on a comparative basis; but with the great field of comparative psychology open before us, the material is more than abundant.

In all this, however, the reality which is described as metapsychic for the one being, is psychic for some other. There can be no doubt that some animals operate in part of our metapsychic field, having, for instance, sensations of smell altogether beyond us. We believe, however, that there is a vast field of reality unrealizable to any living being, and to complete the psychological scheme at the ultra-human end we postulate an all-knowing God. It is a curious question, what must be the psychology of one whose thought circles are all complete, in whose mind there are no attenuated ends of things, fading into the unknown and unknowable. Such a question may be raised, but can hardly be answered by us.

Intellectual progress consists in winning ground from the metaphysic for the scientific, from the metapsychic to the metaphysic. The transition from the third to the first must always be through the second, though its duration therein may be of the shortest. This statement denies, as I think we must deny, the immediacy of knowledge, though not of experience. Knowledge has structure, is built up of varieties of experience, is an organized thing. A single absolutely uniform and monotonous experience, no matter how long continued, could not be a basis for knowledge.

By what process is ground won from the metapsychic? How is the threshold of consciousness overstepped? The mind is a stage, upon which the actors come, and from which they go. Whence are they, and whither do they depart? We can describe in terms of science the accompanying phenomena, but the thing itself evades us. What wonder that mankind has always believed in supernatural, that is, metapsychical agencies!

Reality is a poor word for the totality of being, because it implies to us realizableness. It is only justifiable on the ground just stated, by postulating a being able to know the whole of it. Nevertheless, the practical thing for us is to recognize the continuity of the known into the unknown, without asking what the limits of the latter may be, supposing it to have any.

What is truth? Endless confusion has arisen from the double meaning which has been given to this word. There is practical truth, and abstract truth. The scientific man adheres to the former, the philosopher may talk about the latter.

Science tests things and finds them true, and is only willing to declare them so after examination. Truth then, is the objective side of knowledge, and without knowledge in this sense, there can be no truth. It would conduce to clearness, could we so restrict the meaning of the word, and I believe that in so doing we should have some support from ancient usage. Otherwise, how could we speak of a fact *verified,* made true, if the making true were not a process of the human mind, operating on preexisting reality?

This would leave us with abstract reality, metaphysical and metapsychical reality, but no abstract truth. Truth would be concrete, objective, scientific, something to tie to and act upon. Hence, said William James: "True ideas are those that we can assimilate, validate, corroborate and verify," but he added something to which one need not subscribe, namely, "False ideas are those which we can not." This last postulate would make all ideas false which are incapable of verification, surely an absurd use of the word false. I would rather say that false ideas are those which, having been put through legitimate tests for verification, have failed to pass the examination. False ideas, then, are those which we have tested and could not then verify. Of those which we can not test, or have not tested, it is impossible to say whether they are false or not. Thus we are left with three categories, the true, the false and the candidates for admission into the first group, liable to find themselves ultimately in the second.

The power of verification is apperceptive; we are reminded of Ehrlich's chain-theory to explain certain aspects of proteid metabolism. There must have been an Adam and Eve of knowledge, when two sensations first joined together as the charter members of the society for con-

verting experience, a raw material, into beautiful and marketable truth. Since then the members of this society have closely scrutinized the newcomers, and many have been black-balled. The society is anything but infallible. Not unfrequently it has let in members which afterward had to be ejected with violence, greatly to the discomfort of all concerned. Still more often, I suspect, it has refused to admit worthy candidates who would have been a credit to it. Thus it has come about that many so-called truths are not true at all, for the alleged process of verification was faulty; while supposed untruths may be destined in the fullness of time to be recognized as true.

At this point we must consider the pragmatic doctrine of truth, as expounded by James and others. Pragmatism says, try all things and hold fast to that which is good. Ask always, how does this work? Will it make a good member of the truth-makers' society? It is a doctrine of intellectual dynamics, of activity, of judgment based on knowledge. To this extent it is therefore a wind fanning the flame of intellectual activity, to the end of burning up the dross and extracting the gold. It is the scientific method invading the field of philosophy.

It has, however, a double aim. In testing an alleged truth by its *consequences,* it merely follows the scientific method of determining whether it will, as it should, articulate properly with pre-ascertained truth. It recognizes that *for us,* things are true which have endured the test. This, however, is only the beginning of its quest. It goes further, and asks what things, of those which may be called true, are worth while from a human standpoint. It is inclined to hold, indeed, that this very serviceability is in itself a test of truth. It is for this reason that Professor Schinz calls it "opportunism in philosophy."

The word philosophy, originally signifying the love of wisdom, has come to have many diverse meanings. Quite commonly it is taken to signify a theory of the totality of existence, as, for example, in Haeckel's monistic philosophy. Since it appears that much of reality is metapsychic, a theory embracing the whole of it must be beyond the powers of the human mind, and, as is certainly the case with monism, we find ourselves in possession of nothing more than a point of view. It is, indeed, with the point of view that philosophy must concern itself, and he is a philosopher who has scrutinized and recognized as a whole the landscape visible from his peculiar point of vantage, without necessarily formulating any opinions concerning what is to him unknown. I would therefore say that one's philosophy is one's attitude toward experienceable reality, and inasmuch as every one must have some such attitude, all are to this extent philosophers. One's philosophy, as thus defined, may be consistent or inconsistent, limited or comprehensive, optimistic or pessimistic, active or sluggish, in almost infinite variety. It is obvious that its character determines to a tremendous extent one's person-

ality, or rather, personality is expressed, and its character for others determined, by the attitude taken.

I am not quite sure that the use of the word philosophy in this way, a way that allows us to speak of the *pragmatic philosophy,* is justified, but that is a minor matter, and may be overlooked in our quest for larger game. The important question is, supposing the world converted to this pragmatic philosophy, what would be the consequences, pragmatically speaking? Would pragmatism itself be pragmatically justified?

At the very outset, it must be obvious that a genuinely pragmatic attitude implies for most of us a noteworthy increase in intellectual activity. It is an attitude which obliges us to inquire, test and form judgments. The pragmatist asks *cui bono?* not in the indolent manner of the pessimist, but as the miner asks for the precious metal, and is determined to find it, no matter what the cost. The pragmatist is necessarily an optimist, for his quest implies from the start that the truth is good and serviceable, worthy to be sought. I think the psychologist and the sociologist might have something to say here about the possibility of a breakdown due to too much pragmatism. Are we not protected to a considerable extent by our very stupidity? Human judgment is a two-edged sword, which has often wounded those who used it. Do not our educational efforts indicate to us daily the limitations of the human mind?

It was the belief of William James that most people are capable of much more than they customarily put forth. He was supported in this by examples of heroic effort and achievement under conditions of stress, physical and mental. Our normal performance in these civilized days far exceeds that of our ancestors of a few hundred years back; ancestors who, biologically speaking, did not differ in any important particular from ourselves. The same peoples, living contemporaneously in different parts of the world, differ enormously in their intellectual performance, according to circumstances. It must be admitted, then, that the depths of the human mind have not been sounded, and that much still unsuspected may yet come forth. Whether we like it or not, education and democracy will place us in a position where we must either become more intelligent or go to smash. If we can stand the strain, all will be justified, and humanity will realize values unattainable by any living being at any previous stage in the history of the world. If we fail, the vision of such possibilities will at least remain as a permanent contribution to human welfare, and perhaps a spur to other and more successful efforts in a time far distant.

After all, the pragmatic position does not demand so much of the individual as might at first appear. We are social beings, and in particular our knowledge and judgments are social products. It is equally

unnecessary and impossible for every one to form judgments about everything. A pragmatist need not in any way diminish his regard for authority, provided that this authority represents active inquiry and reasoned judgment. The usages of science suffice to indicate this, for in science there is no arbitrarily constituted authority, and yet the leaders receive their full share of respect. Were we all pragmatists, we should not individually undertake to decide the questions most important for us, but working together we should keenly strive to have them decided on a proper basis. In other words, pragmatism is not only not necessarily individualistic, but must have a socialistic trend if it is to be successful.

For any individual there can be no doubt that a certain ballast due to usage, custom, inertia, or what you will, is necessary. It must be so, also, with society as a whole, and neither for the individual nor for society is it possible to have a complete working philosophy, with all the machinery in view. Mallock once remarked that philosophy is like a coat which can not be buttoned up in front without splitting in the back, and this felicitous image certainly sets forth that inconsistency in the heart of things which has so far baffled all attempts to construct a universal logical system. The reason is, no doubt, that we work only in *some,* not *all,* of the dimensions of reality.

There is, therefore, danger in being too pragmatic. An excess of pragmatic zeal, under the best possible conditions, might possibly lead to the adoption of a too rigid system of values, logically deduced from the physics and metaphysics of the day, but in spite of everything, fatally incomplete. It is the sense of this that gives us pause from time to time, when our intellectual judgment bids us proceed. It has been shown so often that science may stand in her own light, that we have come to regard all things as possibly to be revised. This hesitation, this doubt on the part of those who have done their best for progress, is made the most of by those who cling without thought to the old, and all in all forms too great, not too small, a check on the advancement of the race.

The general outcome of our inquiry seems to be, that if we regard philosophy as an attitude of mind, the pragmatic philosophy may be welcomed as representing a changed emphasis, according well with the spirit and needs of our evolving democracy. At the same time, like every other good thing, it has its dangers, and in some hands it may even be disastrous. As a practical example of pragmatism, we may cite a recent case familiar to all—I mean Mr. Roosevelt's criticism of the Supreme Court. Lawyers had asked, what is written in the law? Mr. Roosevelt asked in truly Jamesian fashion, what difference does it make if this or that decision is rendered? To ask such a question is to find the answer ready at hand, intelligible to the least learned inquirer.

The answer so obtained may even be used to interpret the law itself, having regard for its obvious spirit and intent, rather than the technicalities of some previous case. The pragmatism of nature is expressed through natural selection and the survival of the fittest. It is "the difference that it makes" that decides the fate of a new variation. In the long run, our human virtues and frailties must pass under the same law, but possessing conscious intelligence, we ourselves have a hand in the game hitherto played only by the gods. Having memory and foresight, we can even somewhat improve the ancient process, by considering "the difference" as made in the long run, instead of at the moment only, as is the manner of nature herself.

# THE COST OF LIVING

By HENRY PRATT FAIRCHILD
ASSISTANT PROFESSOR, YALE UNIVERSITY

"THE increased cost of living" is a phrase familiar to almost every American tongue in these days. Newspapers and magazines are full of the topic. A wide variety of investigators are earnestly searching for the causes, and divers explanations have been offered. Over-production of gold, the tariff, the trusts, cold storage and a host of other things have been mentioned—all, probably, with more or less of truth. Yet it is amazing to note how little attention has been paid to the most obvious and easily comprehended cause of the high prices of one great class of commodities, *i. e.*, the food of the people. This is by far the most important aspect of the problem, and its primary and fundamental explanation lies in a perfectly simple and concrete fact—namely, the increasing proportion of the population of the United States which may be classed as city dwellers rather than country dwellers; in other words, the preponderance of the urban population.

The food element of the high prices problem is so thoroughly predominant in all discussions of the topic that one might almost say that, in the popular mind, the high cost of living is synonymous with the cost of food. The high prices which are causing such consternation in the families of the land are the prices of meat, eggs, butter, milk, bread and vegetables, and it is to this class of commodities that the following considerations apply most directly. These are all, primarily, the products of the country. We may then carry our analysis a step further and say that the cost of food is the cost of agricultural products. It may be observed, in passing, that many other necessaries of life, beside food, are products of the country. In fact, practically every commodity is derived ultimately from the land, and what is true of food is more or less true of other commodities, in proportion as they are the products of the extractive, rather than of the manufacturing industries. At the same time, most of the present discussion of this topic centers around that class of commodities, originally mentioned, which make up the food supply of the nation, and are directly the result of the application of labor to land. It is to this group that we wish to confine our main discussion.

Let us hasten, however, to disclaim any inclination to minimize the value of the contribution which is made to the wealth of society by the manufacturer, the merchant and others engaged in distinctively "city"

occupations. The old idea of the school of French economists, known as the physiocrats, that land is the source of *all* wealth, undoubtedly served a useful purpose at the time, but was long ago abandoned. To-day we readily recognize that any person engaged in any occupation which adds to the total enjoyment of mankind is a truly productive laborer. The drygoods clerk, the manufacturer of shoes, the bank president and the opera singer all make additions to the wealth of society, just as truly as do the farmer and the dairyman. We even go further, and assert that the greatest total wealth of society can be produced only when the efforts of the agricultural classes are supplemented by a certain proportion of laborers in industrial, professional and mercantile fields—the avocations of the city. But there comes a point in the economic development of a nation when the number of those engaged in city occupations—including the occupation of spending time, indulged in by the idle rich and the unemployed poor, who throng the cities—becomes excessive, and overbalances the number of country workers. Have we reached this point in the United States?

The price of food stuffs, like that of every other commodity, is governed by the laws of supply and demand. Assuming stable conditions of fertility of soil, of climate, and of methods of production, the price of agricultural products depends on the proportion between those who produce them and those who consume them. Broadly stated, this is the proportion between the country dwellers and the city dwellers. This proportion in the United States has been rapidly changing within the last century in the direction of the preponderance of the urban class.

When the first census was taken in 1790, there were only six cities with over 8,000 population each, containing in all 131,472 persons, or 3.4 per cent. of the total population of the United States. In 1840 the percentage in cities of the specified size was still only 8.4. But in 1900 there were 545 cities of over 8,000, in which dwelt 33.1 per cent. of the total population. The significance of these figures becomes more evident if we consider the proportion between the urban and rural populations at different dates. In 1790, for every inhabitant of the cities of the specified size, there were 28 persons living in the smaller towns and in the country districts. Fifty years later, there was one city dweller to every eleven country dwellers. By 1880 the proportion had reached 1 to 3.4 and at the last census, in 1900, for each inhabitant of the cities there were only *two* dwellers in the country! Is it any wonder that the cost of agricultural products has gone up? The marvel is that prices did not go up long ago, or that they have not reached a much higher figure.

It may appear that the foregoing explanation is inadequate to account for the suddenness of the rise in prices within the last year or two. To this objection, there are two or three replies. During the last half of the nineteenth century the tendency of prices to rise was offset

by improvements in the arts of agriculture, and by the cultivation of new and better lands in the west. The crisis of 1907, by depressing conditions in general, caused a temporary retardation in the upward movement, making it more pronounced as prosperity returns. Moreover, the critical point in the proportion between the urban and rural classes is one which may be reached and passed in a brief period of time. Apparently we have just reached, or are just passing, this juncture in the United States. Finally, the explanation herein offered does not claim to be a complete one. For such a complicated phenomenon, there is undoubtedly a variety of causes, each with its own importance. But the division of population between city and country is the underlying condition which has made the operation of the other causes possible.

At this point the question naturally arises, why does not this state of affairs work out its own cure? Why does not the high price of farm products, bringing, as it apparently must, large profits to the farmer, make country life more attractive, and check the rush to the city, or even entice some of the urban dwellers back to the soil?

The first and most obvious answer to this query is that by no means all the profits accruing from the high price of food ever find their way back to the pockets of the original producer. Farmers have never been able to secure for themselves, for long periods of time or over large areas, the benefits of combination. Under our modern system of supply, the products of the soil pass through a number of different hands before they reach the consumer, and each of the intermediaries must have his profit. A large part of the excess of price over the actual cost of production is absorbed by transportation companies, commission merchants, packers and retail dealers—themselves mainly city dwellers.

But this is only a very partial explanation. The factors which determine residence in city or country are something more than the financial advantages which this or that locality has to offer. That the opportunities for achieving marked success in business, and amassing huge fortunes are greatest in the centers of population is undoubted, and the decision of many a country lad to break away from the familiar home surroundings is forwarded by the hope that he may be one of the fortunate ones who find their place in the city, and win great rewards. Occasionally it turns out so. But it is a question whether the average young man stands a better chance of making a comfortable living in the city than on the farm, and monetary considerations alone could hardly exert such an attractive force as we see in operation.

The lure of the city is something infinitely more complex and intricate than this. A complete and adequate explanation of its power has long been sought in vain. Some of the elements of its irresistible charm are obvious, and may be easily stated—the excitement and variety of metropolitan life, the opportunities for recreation and diversion, the comforts of city houses, the chances for achieving success and fame in

many fields, the busy whirl of commercial and social life—but after all, what is all this more than to say, "the fascination of city life"?

There is one condition, however, which has undoubtedly done much to intensify the situation and aggravate the difficulties. That is the immense immigration of the last quarter of a century, particularly of the last decade. The immigrants of an earlier generation—the Germans and the Scandinavians—went west in large numbers and took up farm lands, making an effective and valuable addition to the ranks of agricultural producers. Our modern immigrants settle in the most densely populated states, and in the largest and most congested cities. In 1890, 61.4 per cent. of the foreign-born population of the United States were living in cities of at least 2,500 population. In 1900 the percentage of foreign-born in cities of like size was 66.3, while of the 10,341,276 foreign-born residents of the United States in that year, 38.8 per cent. were huddled in the few great cities having a population of over 100,000. When we consider that only 15.5 per cent. of the native-born population were in cities of that size, it becomes evident how seriously the immigration movement affects the proportion between city and country dwellers—in other words, the cost of living. The census of 1910, after a decade of immigration unparalleled in the history of the nation, will undoubtedly show conditions even more striking and appalling.

The comparatively small increase in the proportion of city dwellers from 1890 to 1900 (from 29.2 per cent. to 33.1 per cent.) may be partially explained by the very slight gain in population through immigration during that decade, while the tremendous immigration of the last few years may largely account for the suddenness of the jump in prices.

To discuss possible remedies for the situation is apart from the purpose of the present paper. A few years ago, when the country telephone, rural free delivery, and the inter-urban trolley began to come into common use, great hopes were expressed that together they would help to solve the situation by promoting communication and fellowship among rural families, breaking up their isolation, and thus making country life more attractive. The results so far seem to have fallen far short of the anticipations. As for the immigrants, a few of the Italians are beginning to take up market gardening in the neighborhood of the great cities, but this movement is very slight as yet. All the efforts of colonization or removal societies, philanthropic organizations, and of the United States government, have produced almost inappreciable effects in securing a better distribution of the foreign-born.

What the future may bring forth in the way of increasing the attractiveness of the country for natives or aliens, time alone can tell. But as long as the rush to the cities continues with unabated or increasing force, it is vain to hope that the cost of food will fail to augment at a corresponding rate.

# ALCOHOL—ITS USE AND ABUSE[1]

By Professor GRAHAM LUSK
CORNELL UNIVERSITY

WHEN the writer was a former student in Munich about 1890, there was a very great quantity of beer partaken of by the inhabitants of the town, and also by the German people in general. The "beer duel" consisted in draining a large jug of beer which was lifted from the table at a given sign, and he who first brought the empty jug back on the table was the winner of the duel. In fact, the writer has heard pleasure measured in terms of glasses of beer partaken. For example, such and such a holiday trip on the Rhine could not be indulged in because it cost the equivalent of so and so many glasses of beer.

A considerable change in the manners of the people was noticed on a visit to Germany in 1906. At a luncheon in Heidelberg, both lemonade and white wine were placed on the table, and the white wine was scarcely touched. This great change has been due to two factors. There has been great development of what the Germans call "Sport." The young men indulge in an out-of-door life to a very much greater extent than formerly. Skiing among the Alps in the winter-time, for example, is something which is the delight of many of the students, and all this has tended to decrease on their part the quantity of alcohol consumed. A second powerful influence is that of the Kaiser's edict that his health can be drunk in water. As long as it was impossible to drink the Kaiser's health in water without its being considered a dire and fatal insult to His Majesty, just so long was it impossible for the development of a temperance spirit.

Besides these factors, the physiologist Bunge has for many years railed at those who would partake of the excreta of yeast, and Friedrich Müller and Kraepelin of Munich have neither of them lost an opportunity before their medical classes to drive home the evils accompanying excessive drinking. They have done this to the great trepidation of the beer brewers of Munich.

At a recent lecture in London, Dr. Mott has said that it was desirable to approach this subject in a scientific spirit and without prejudice, and following him, Sir Clifford Albutt has called attention to the fact that much of the literature of alcohol is of a rhetorical rather than of a

[1] Annual address before the Alpha Omega Alpha Society of the University of Pennsylvania.

scientific order, and has stated that the sooner scientific order and method are introduced the better.

Alcohol is frequently used as a flavor for food. Pure alcohol itself is never taken, but the various alcoholic beverages are prized on account of their various flavors. There is no more powerful stimulant to the flow of the gastric juice than alcohol. Introduced directly into the small intestine or even into the rectum, alcohol may produce a flow of gastric juice. However, it has been shown that a single glass of wine containing between five and ten per cent. of alcohol is as effective as a stomachic as when much larger quantities are ingested. Indeed there can be no doubt that the healthy stomach needs no such stomachic whatever. This is known, because the materials of which ordinary food consists are perfectly digested and perfectly absorbed without recourse to anything beyond the ordinary flavors of the table.

In cases where there is no appetite, it may be that a single glass of wine may help the digestion of food. So Pawlow describes that when he was convalescent from a fever and could digest nothing, a glass of sherry brought about an initial flow of his gastric juice and with its aid digestion of the food was possible. It is stated that the value of a liqueur which is taken with after-dinner coffee, lies merely in its irritant action upon the wall of the stomach—an action which promotes a discharge of material from the probably too well-filled stomach of the individual who has been dining.

Alcohol is also a nutrient material. The publication by Atwater and Benedict showing that alcohol could replace other foodstuffs in nutrition, led Mr. Dooley to remark that his saloon was really a restaurant. In normal nutrition the cells of the body are provided with fuel by fat or by sugar. When protein is given, most of it is converted into fat or into sugar within the organism. So, in the ultimate analysis, it is found that the motions of the cells, which motions constitute life, are maintained at the expense of fat and carbohydrates. When these are oxidized, energy is liberated which impels to motion the particles of protoplasm, and these motions constitute the machinery of life.

Atwater and Benedict gave a man ordinary food for thirteen days. The food contained 2,496 calories, and the man destroyed materials within himself, so that he daily produced 2,221 calories. On this diet, he retained within his body 33.7 grams of fat daily. Then the same man was given a diet for ten days which had the same number of calories as before, but only 1,996 of these were in the ordinary food materials, whereas 500 calories were in alcohol. This quantity of alcohol is what would be found in a bottle of claret. The alcohol was given in six small doses daily. The alcohol was almost completely burned, only a small quantity appearing in the urine and breath. The heat production during this second period, amounted to 2,221 calories daily

or exactly the same as in the previous normal experiment. The quantity of fat retained by the patient on the alcohol days amounted to 34.1 grams daily. It is evident from this experiment that alcohol can replace fat or carbohydrates in metabolism in accordance with its heat value. So we can say that the cells of the organism may be maintained in their vital activities by alcohol instead of by normal nutrient substances.

It is apparent, therefore, that alcohol may have a very considerable value as food. If an alcoholic beverage should contain materials other than alcohol such as the extractive materials in Bavarian beer, the food value rises to a very considerable amount. Thus, a liter of Bavarian beer contains 450 calories. These facts, however, do not at all justify the substitution of alcohol for carbohydrates and fats in the dietary.

Many experiments have been accomplished to see whether alcohol has any effect upon the protein balance in the body. Sometimes alcohol has been found to spare protein, sometimes it has been found to cause a waste of protein. The effect, however, of alcohol upon the general metabolism of protein is certainly without very great significance.

Yet there are indications that alcohol does alter metabolism in the individual who partakes of it. Beebe found no effect upon the output of uric acid after taking alcohol with a diet which was free from the precursors of uric acid. This, however, has not been confirmed by others, and Landau found that usually there was a slight increase in the output of uric acid in the urine after the ingestion of alcohol.

Since the nucleus of the cell is characterized in its structure by the presence of nucleo-proteins whose destruction results in the increased elimination of uric acid, it is not impossible that these nuclei are somewhat affected by the presence of alcohol in the body. A similar effect upon the nuclei of the germ plasm may be considered in connection with the idea of the possible transmission of alcoholism through heredity.

Abbott has found that alcoholized rabbits not only show the effect of streptococcus inoculations earlier than do non-alcoholized rabbits, but the lesions produced are much more pronounced than those which usually follow inoculation with this organism.

Laitinen has administered to rabbits one cubic centimeter of pure alcohol per kilogram of body weight, which corresponds to between four and five ounces of whiskey daily for a man. This quantity of alcohol was not sufficient to intoxicate the animal. Animals which had received this amount of alcohol for a considerable period were found to have a much greater susceptibility to pathogenic bacteria than normal controls.

Hodge has found that alcoholic dogs show diminished resistance to distemper as compared with normal animals under the same kennel conditions.

Richards has shown that if the hearts of dogs which have received alcohol for some time be perfused with a nutrient solution containing alcohol, they are much more sensitive to alcohol than hearts of normal controls.

Another experiment which shows apparent change in the organism under the influence of alcohol, has been accomplished by Reid Hunt. Hunt determined the toxic dose of aceto-nitrile $CH_3CN$ in mice, rabbits and guinea pigs. This substance acts as a poison through the liberation of hydrocyanic acid within the body. Hunt found that if animals were given alcohol for several days, their susceptibility to aceto-nitrile was very greatly increased. That is to say, hydrocyanic acid was much more readily liberated within their tissues than in the normal controls. Hunt interpreted this as indicating an increased oxidative power on the part of the cells for the methyl group contained in the poison. However this may be, it is certain that his experiments have shown that metabolism is different when alcohol is given than it is under conditions when fat and carbohydrates form the energy producers which maintain life.

Alcohol has long been given in disease on account of the belief that it was of benefit in certain disturbances of the circulatory system. The value of alcohol under these circumstances has been disputed. The reports of the Vienna General Hospital in 1897 show that $10,000 was spent for alcoholic beverages during that year, whereas in 1905, the sum so expended had fallen to one half. Dixon says that alcohol acts uopn the isolated heart as a food stuff, and favors its contraction. A recent discussion of this subject by Miller, of Chicago, shows that circulatory disturbances in acute affections are of vaso-motor origin, and that the heart itself is usually perfectly able to fully perform its work. He calls attention to the fact that alcohol in certain diseases acts as a cardio-vascular stimulant producing vasco-contraction of the blood vessels and thereby favoring the circulation. However, if the dose which brings about this reaction be but slightly exceeded, there is paralysis of the vaso-motor centers with resulting dilatation of the blood vessels. He regards alcohol, therefore, as a drug which is to be used in these conditions with extreme care.

Alcohol has a profound effect upon the central nervous system. There are two theories with regard to its action. By some it is considered a stimulant, by others it is thought always to cause depression. Small amounts of alcohol may bring about an increased sense of liveliness and a general feeling of well-being which is most pronounced when the lights are bright, and the company congenial. Larger quantities induce incoordination of speech and movement, whereas still larger quantities result in complete anesthesia which may be fatal to the individual. For the first few minutes after taking alcohol, it has been found

that a larger quantity of physical work may be performed. This is followed, however, by a period of depression during which the quantity of mechanical energy which may be expended by the individual is greatly reduced. The sum total of the effect is very decidedly to reduce the amount of mechanical work which can be accomplished during the day. It is on this account that alcohol is no longer given to soldiers on the march in the hope of increasing their endurance. The actual result would be quite the contrary.

Experiments regarding the action of the brain after taking alcohol as compared with its action before taking alcohol have been made by Kraepelin. Typesetters were used as subjects. It was found that those who had partaken of alcohol made a greater number of errors and worked less rapidly than those who were abstemious. Kraepelin has found that this effect lasts as long as twenty-four hours after alcohol has been taken. Curiously enough, those who had taken alcohol thought they were doing their work to better advantage than those who had not.

Other experiments have been made upon people, the test being the length of time which was required to memorize twenty-five lines of poetry. Here, when alcohol was taken before breakfast, it was found that the length of time required to memorize was increased 69 per cent. Also, when these individuals were requested to repeat the lines which they had learned, it was found that they did so less readily and made more errors when they had previously taken alcohol, than when they were free from the effect of this drug.

It is very apparent from such experiments as these, that alcohol does not stimulate to mental activity. The theory of Schmiedeberg is that the effect of alcohol is always a depressant one. The first depression upon the mind acts upon those highest faculties which are developed latest in life. That is, the faculties of self-control and self-respect. If these faculties are paralyzed first through the depression of alcohol, then it is as Cushny has pointed out, as though the brakes were removed from the mind, and the man becomes a child again. He becomes regardless of the ordinary conventions of life, regardless of the feelings of other people, regardful of himself alone. It is easy to see that where restraint is removed from the mind so that the normal action of self-control is abolished, the individual becomes open to all kinds of suggestions which he otherwise would not suffer. The mental condition is truly pathological.

It is thus that alcohol becomes the principal power behind prostitution. It is thus that the saloon in politics becomes dominant. The saloon through the alcohol which it furnishes is perfectly able to reduce the self-respect of the individual to such a level that he is glad and willing to accept a bribe for his action with regard to a political matter. It is easy to see to what extent alcohol becomes the auxiliary of crime.

It is stated that 60 per cent. of the crimes of violence are due to drink. All these various activities which are due to alcohol tend to break up homes, and indeed Cushny has stated that if alcohol were a new synthetic drug imported from Germany and a few cases of alcoholism had been discovered as resulting from it, there would be such an outcry against it that it would be forever prohibited. A much more valuable drug, cocaine, he says, has nearly come to this fate on account of a few isolated cases in which the cocaine habit has been formed. The writer is not a teetotaler, and yet he does not think that any one can listen to an exposition of the effects of alcohol without being willing to join in a movement for its entire prohibition, provided such a prohibition could be really effective. The trouble, of course, with such movements has been that prohibition has not in reality prohibited.

The English medical journals have of late contained several articles regarding the relationship between alcohol and insanity, and also between alcohol and heredity. Dr. Mott, who is both a physician and a pathologist, quotes from Dr. Branthwaite, that 62 per cent. of the alcoholics committed to reformatories under the English Inebriates' Act, are found to be insane or mentally defective. However, Dr. Mott is very unwilling to believe that alcohol is the cause of insanity in any such proportion. He attributes the statistics mentioned above to the marked intolerance of the mentally defective for alcohol. Dr. Mott has made many autopsies in connection with his service at the Charing Cross Hospital and the Claybury Insane Asylum. In the general service of the Charing Cross Hospital he has found cirrhosis of the liver in about 7.7 per cent. out of a total of 1,099 adult autopsies, whereas at the Claybury Insane Asylum, out of 1,271 adult autopsies he has found only 1.8 per cent. of cirrhosis of the liver. In the asylum he has had only one case of cirrhosis of the liver with ascites, and this person had been convicted 400 times in the criminal courts before having been declared insane.

Among the hospital patients, on the contrary, there were many cases of cirrhosis of the liver with ascites. Mott therefore comes to the conclusion that a person who can drink to a condition of advanced cirrhosis of the liver has inherited an inborn stable mental organization. Such individuals he finds may exhibit no previous mental symptoms beyond a weakened will and a loss of moral sense. He says there can be no doubt that neurasthenics, epileptics, imbeciles, degenerates and potential lunatics possess marked intolerance for alcohol, and failure to discriminate between what is hereditary and what is the result of alcoholism has been the cause of much confusion. Those who are alcoholics and show only weakened will-power and failing memory do not necessarily become permanently insane.

Hodge has given dogs alcohol from puppyhood to maturity in such

quantities as to materially reduce their mental ability, but on the withdrawal of alcohol, normal intelligence was awakened.

Statistics have been collected which show that in the mining counties of England there is much alcoholism and little insanity, whereas in the country districts the reverse is true. The explanation given by Sullivan is that the more feeble minded among the English stay in agriculture and procreate their species, whereas the more intellectually active move to the town environment. So it may be, that perhaps no more than 10 per cent. of the insane are really produced by the direct action of alcohol, the rest having inherited conditions of weak intellectuality.

A further question is the action of alcohol on heredity, a matter which has been taken up by some of the most prominent English authorities. The question is, does parental alcoholism influence the physical and mental ability of the offspring. This question is discussed by Hyslop in a recent number of the *Lancet*. It is still doubtful whether the heritage from alcoholic parents is due to the alcoholism or whether it is due to the inherent parental degeneracy with the accompanying tendency towards alcoholism, and here again one must consider the association of the child with its alcoholic parent usually in an unwholesome poverty-stricken environment. Hodge has demonstrated that alcoholized dogs give birth to offspring of low vigor and low viability.

It is stated that the only true solution of this question in human beings is to be obtained through a number of instances in which children have been born to parents before the alcoholism, during alcoholism and after recovering from alcoholism. Such experimental conditions, of course, are not to be thought of as premeditated, and the history of such cases as actually occur in the tragedy of life are only with difficulty obtainable with accuracy. It is but recently that hereditary studies have been made on the subject of the color of the eyes, of the hair, and in other problems the work of necessity becomes more and more complicated. However, such statistics as have been collected seem to indicate that with each successive generation addicted to alcoholism there is a shorter period of existence before alcoholism sets in in the offspring. Thus Hyslop says that parental alcoholism accentuates the downward trend of an inherited neurosis and physical degeneracy.

There can be no doubt that this question of the use and abuse of alcohol is one of the most serious with which the modern world to-day has to deal.

# SCIENTIFIC VERSUS PERSONAL DISTRIBUTION OF COLLEGE CREDITS

By President WILLIAM T. FOSTER

REED COLLEGE, PORTLAND, OREGON

EARLIER articles in the Popular Science Monthly and in *Science* have shown that grades in college courses have no exact meaning.[1] Yet college honors are everywhere awarded on the naïve assumption that grades in college courses are distributed on a scientific basic. For many important administrative purposes we assume that an A in one course is equivalent to an A in another course; that the 80 per cent. of one instructor indicates an achievement equal to the 80 per cent. of another instructor. Accordingly, we estimate the fitness of candidates for admission, determine eligibility for athletics, assign annually hundreds of thousands of dollars in scholarships and fellowships, award commencement honors, elect men to Phi Beta Kappa, and confer degrees wholly, or in large part, on the evidence secured by merely counting the number of As, the number of Bs, and so forth, that each student has to his credit. The question is pertinent to what extent our assumption of the equivalency of grades is warranted by the facts.

Our universities and colleges vary so little in this phase of the administration of the curriculum that the detailed distribution of the grades of a few institutions for a few years will fairly represent the practise, except in two or three universities, throughout the country. The grades A, B, C, D usually represent degrees of excellence between 100 per cent. and 60 per cent. of some undefined thing and are all pass marks. The grade E commonly indicates failure. In the figures here presented, the grades have these meanings. The per cent. of the students in each subject who receive each grade is graphically shown, so that a glance reveals the central tendency for each grade in each institution and the extreme deviations in both directions. In all cases the names of instructors and the exact designations of the courses are omitted, at the request of the several institutions concerned; though one may be pardoned the query, what objections could there be to publicity, if grades were distributed on a defensible basis.

Figs. 1 and 2 show the proportion each grade is of the whole number given at Harvard College in each of the elementary courses in twenty-one subjects during one academic year. Thus, the range of the highest

[1] Popular Science Monthly, Vol. LXVI., pp. 367–378, 1905, by J. McKeen Cattell. *Science*, N. S., Vol. XXVIII., No. 712, pp. 243–250, 1908, by Max Meyer.

TABLE I

HARVARD COLLEGE

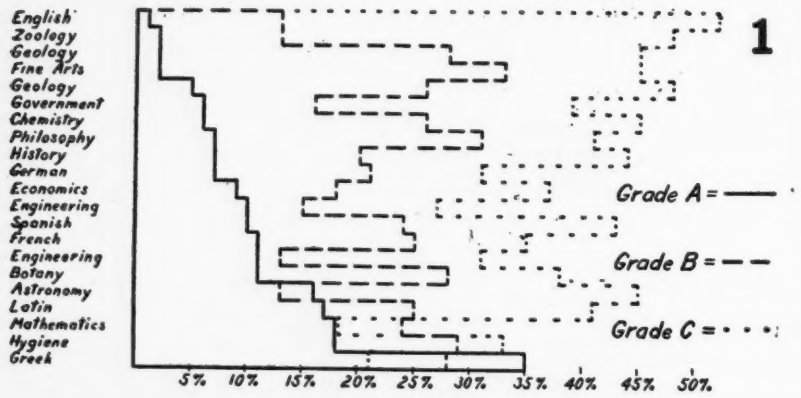
*Distribution of 8,969 Grades, Elementary Courses*

| Group 1 | % A | % B | % C | % D | % E | % Abs. | Total |
|---|---|---|---|---|---|---|---|
| Astronomy | 16 | 13 | 45 | 19 | 6 | 1 | 69 |
| | 10 | 17 | 48 | 17 | 7 | 2 | 130 |
| Botany | 11 | 28 | 38 | 14 | 2 | 7 | 183 |
| | 4 | 32 | 44 | 13 | ½ | 6 | 219 |
| Chemistry | 6 | 26 | 45 | 12 | 9 | 2 | 334 |
| | 8 | 19 | 45 | 17 | 11 | 0 | 319 |
| Economics | 10 | 18 | 37 | 25 | 7 | 3 | 531 |
| | 7 | 19 | 43 | 21 | 7 | 3 | 436 |
| Engineering | 11 | 15 | 31 | 28 | 12 | 3 | 114 |
| | | | | | | | 121 |
| Engineering | 10 | 13 | 27 | 21 | 21 | 9 | 139 |
| | | | | | | | 129 |
| English | 1 | 13 | 52 | 28 | 3 | 3 | 603 |
| | 1 | 11 | 51 | 32 | 3 | 3 | 564 |
| Fine Arts | 2 | 33 | 45 | 10 | 2 | 9 | 58 |
| | 6 | 27 | 67 | 0 | 0 | 0 | 49 |
| French | 11 | 25 | 35 | 21 | 4 | 4 | 156 |
| | 12 | 19 | 36 | 19 | 10 | 4 | 145 |
| Geology | 5 | 26 | 45 | 20 | 3 | 2 | 489 |
| | 5 | 25 | 33 | 28 | 2 | 7 | 85 |
| Geology | 2 | 28 | 48 | 10 | 7 | 5 | 122 |
| | 4 | 20 | 43 | 24 | 7 | 2 | 108 |
| German | 7 | 21 | 31 | 26 | 11 | 4 | 259 |
| | 6 | 14 | 32 | 27 | 17 | 2 | 293 |
| Government | 6 | 16 | 39 | 28 | 8 | 3 | 356 |
| | 9 | 23 | 37 | 21 | 7 | 2 | 419 |
| Greek | 35 | 28 | 21 | 13 | 1 | 3 | 72 |
| | 15 | 36 | 34 | 7 | 5 | 3 | 61 |
| History | 7 | 20 | 44 | 21 | 5 | 2 | 347 |
| | 7 | 24 | 42 | 20 | 6 | 2 | 380 |
| Hygiene | 18 | 29 | 33 | 18 | 1 | 0 | 87 |
| | 8 | 23 | 48 | 14 | 4 | 3 | 139 |
| Latin | 17 | 25 | 41 | 10 | 7 | 0 | 143 |
| | 15 | 27 | 41 | 5 | 10 | 2 | 128 |
| Mathematics | 18 | 24 | 18 | 31 | 11 | 0 | 85 |
| | 14 | 22 | 31 | 23 | 11 | 0 | 95 |
| Philosophy | 7 | 31 | 41 | 15 | 2 | 5 | 229 |
| | 7 | 23 | 61 | 8 | 0 | ½ | 215 |
| Spanish | 10 | 24 | 43 | 16 | 4 | 3 | 106 |
| | 7 | 13 | 38 | 33 | 8 | 2 | 119 |
| Zoölogy | 2 | 13 | 48 | 30 | 5 | 1 | 149 |
| | | | | | | | 184 |
| Average | 7 | 20 | 42 | 21 | 7 | 3 | 213 |

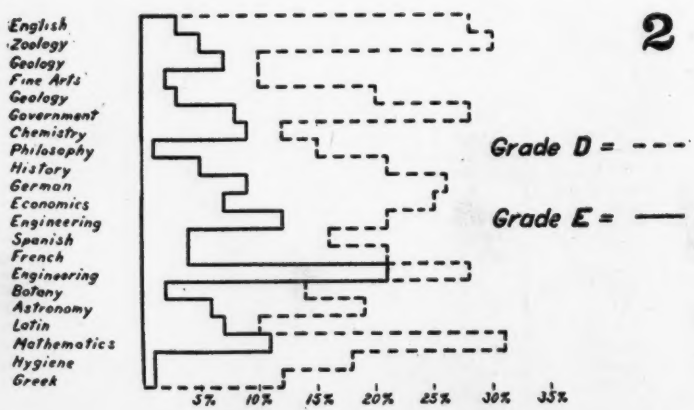
credit (A) is from one per cent. in English to thirty-five per cent. in Greek. The range of grade B is from eleven per cent. in English, zoology, engineering and astronomy to thirty-three per cent. in fine arts. Grade C shows a minimum of eighteen per cent. in mathematics and a maximum of fifty-two per cent. in English. Grade D ranges from ten to thirty-one; grade E, from one to twenty-one. Courses with fewer than one hundred students are omitted, as the smaller courses are not fairly comparable in a single year with the larger ones on a percentage basis.

Still further to safeguard our comparisons, the intermediate and

advanced courses are grouped by themselves. Some men believe that the credits in an advanced course, which to some extent represents the survival of the fittest students in the department, should be differently distributed from the credits in an elementary course in the same subject. College records everywhere show that a larger proportion of the




high rank men than of the low rank men, in an introductory course, continue the subject in advanced courses. Indeed, one of the chief objects of the elective system is to enable students to specialize in fields in which they are likely to achieve distinction. But this hardly justifies the extreme and continued variations among the grade distributions of the intermediate group of courses, nor does it account in a sat-




isfactory way for the diverse practises among advanced courses. Figs. 3 and 4 show a variation of two per cent. to sixty per cent. in the As given in intermediate courses in Harvard College; and extremes of seventeen per cent. and seventy-four per cent. in the case of grade B, Fig. 4 pictures the statistics of grades C, D and E.

Table II. indicates the comparative distribution of grades A–E for the three groups—elementary, intermediate and advanced.

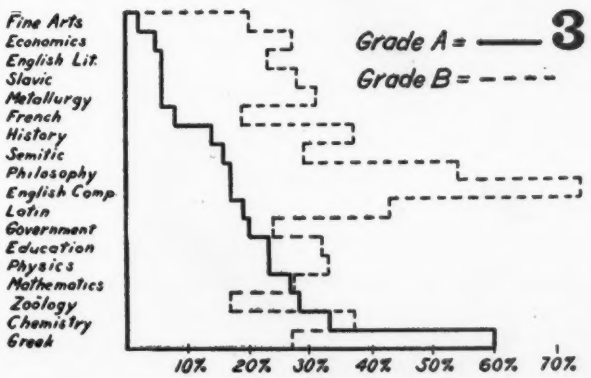
TABLE II

HARVARD COLLEGE

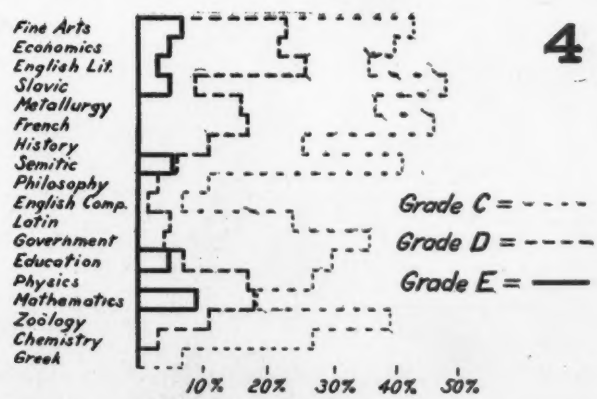
*Distribution of all Grades for Two Academic Years*

| Totals | % A | % B | % C | % D | % E | No. of Grades |
|---|---|---|---|---|---|---|
| Group I. | 7 | 20 | 42 | 21 | 7 | 8,969 |
| Group II. | 12 | 28 | 37 | 13 | 4 | 2,456 |
| Group III. | 36 | 38 | 13 | 2 | 2 | 476 |

Not only are there extreme variations among different courses, but there are variations in the same courses from year to year that can not be accounted for, apparently, by any of our scientific studies in the




distribution of abilities among human beings. Fig. 5 shows the per cent. of As and the per cent. of Bs given in each of 53 courses at Har-




vard College for 1906–07 contrasted with the same data concerning the same courses for the following year. The data are taken from the published rank lists and from the enrollment in courses as given

annually in the president's reports. A glance at the graphs in Fig. 5 reveals the fact that eight or ten courses show marked changes from one year to the next, whereas in eighty to ninety per cent. of the courses there are only negligible variations.

Another fact revealed in Fig. 5 is worth noting here. The six courses reaching highest in the A group are as follows: courses in Greek,

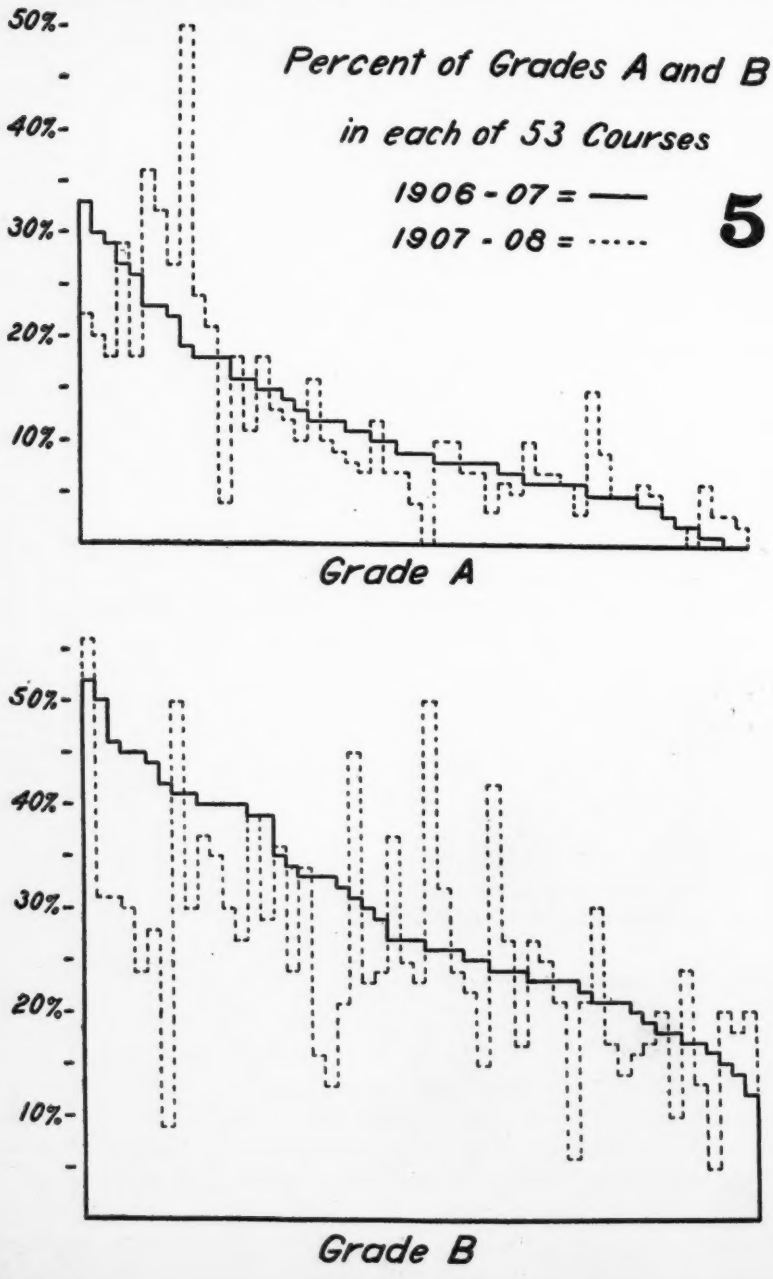
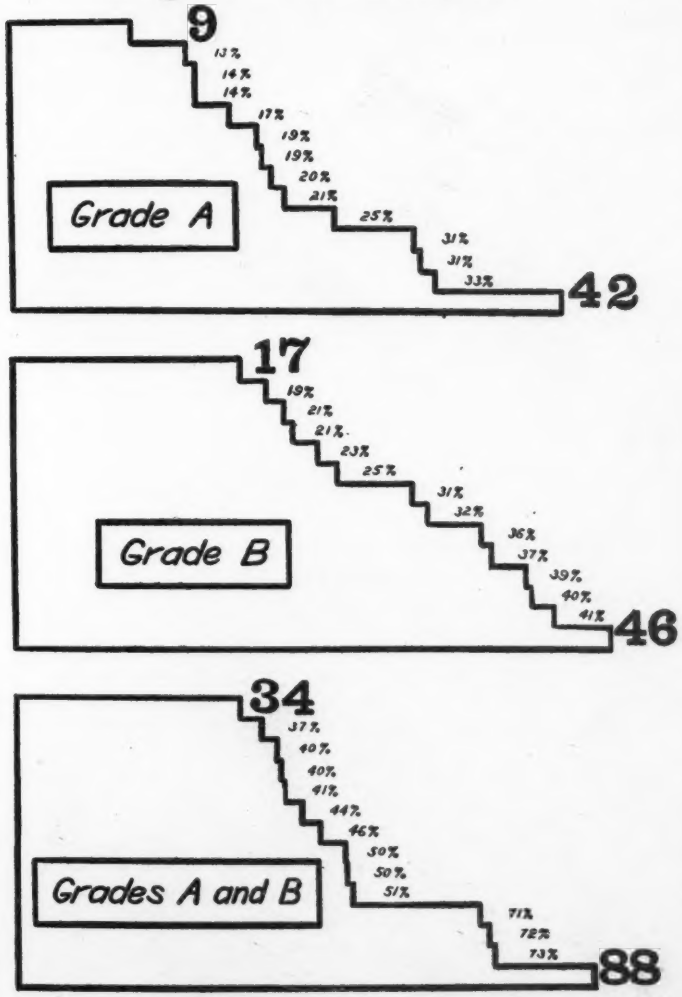


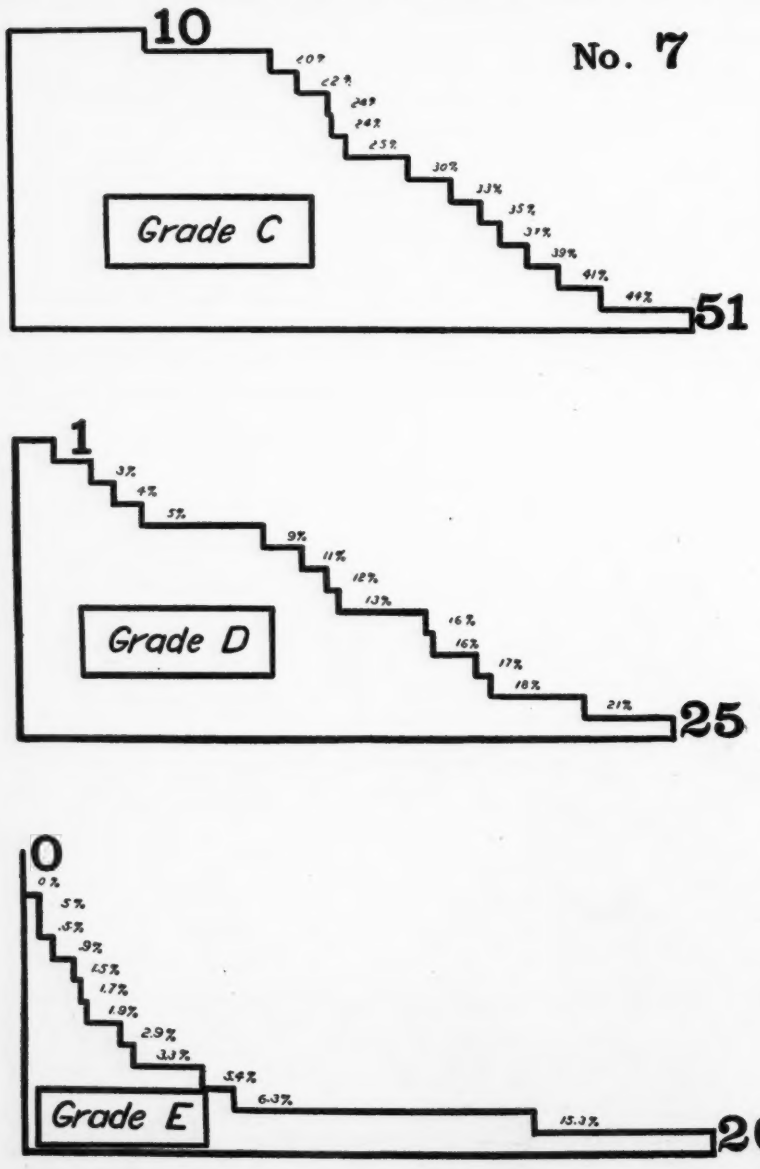
Figure 6 Showing Percentages of Various Grades in Total Grades of each Instructor having over 100 Students




Greek, Italian, Greek, Greek, Latin. The exact designations are withheld because of the respect of the administration for the feelings of individual instructors. Nevertheless, students are encouraged to examine the published rank lists, in which he who runs for high grades may read his chances. Reference to Fig. 1 shows that in 1903–04, as well, Greek far surpassed all other subjects in awarding high marks.

Figs. 6 and 7 show the range of percentages for each grade, A–E, for each instructor in Bowdoin College, Maine, giving in 1907–08 over

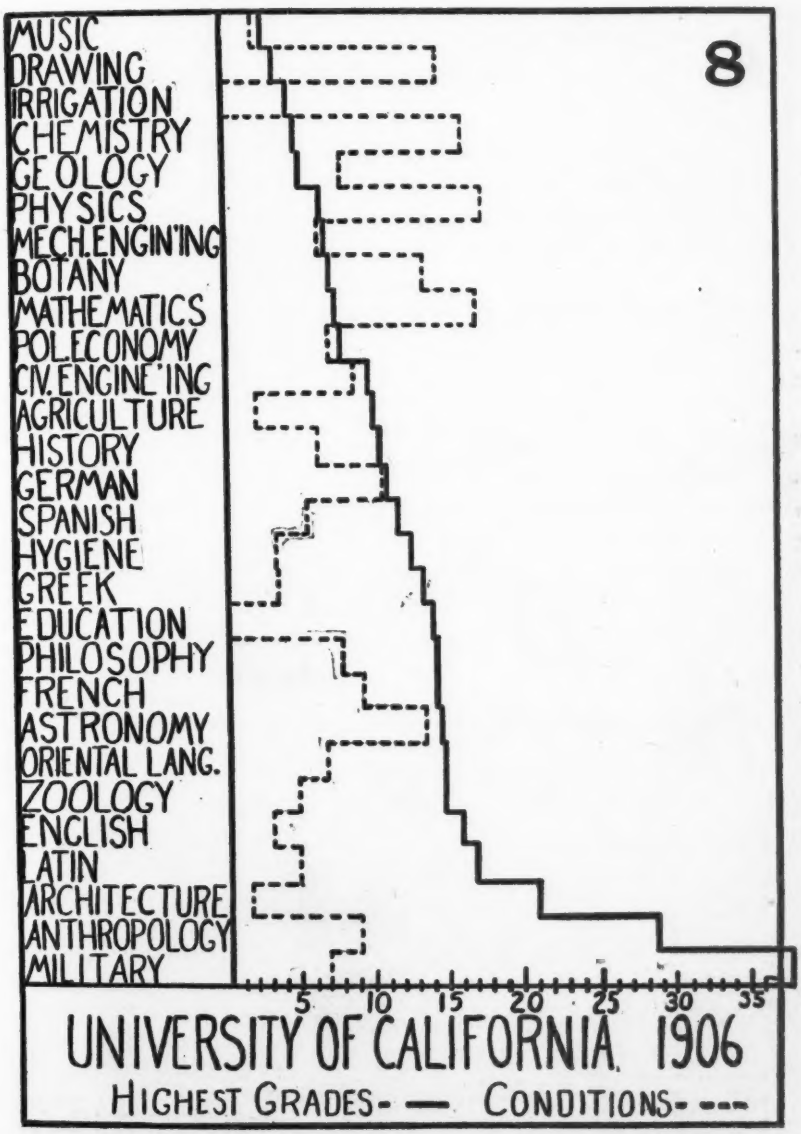
one hundred grades. Fig. 8 gives the distribution of highest grades and of lowest grades, the honors and the failures, for various departments at the University of California in December, 1906. It is unnecessary to present statistics for other years or for other institutions. From Maine to California the administration of college credits, though




alike in no other particular, agrees in this—that its basis is personal rather than scientific.[2] We do not know what the symbols mean: they

[2] W. F. Dearborn, in Bulletin 368 of the University of Wisconsin, presents numerous unscientific distributions of grades in Wisconsin.

have no defined meaning. To reply that a given symbol signifies a certain per cent. of an undefined something is to beg the question. The administration of the curriculum on a percentage basis—giving grade B in Greek, for example, a value of 80 to 90 per cent.—is apparently exact, but in reality far from it.




We have here used the statistics of institutions which do not attempt to grade students in many groups. The usual school method of grading on a one-hundred-per-cent. basis produces confusion. As a matter of fact, teachers can not use more than a dozen grades with discrimination.

This has been proved repeatedly by careful tests, and is evident from the erratic clustering of grades around arbitrary points on the scale in every school where the attempt is made to use a scale with thirty or more divisions.

Individual instructors, in defense of their extreme variations from the mean proportion of high and low grades, often assert that the students who elect their subjects are much better than the students who elect other courses. Figs. 2 and 8 seem to indicate that quite the opposite is the truth. The poorer students elect a larger proportion of their work than the better students from courses in which the number of *high* grades given is relatively large. The better students elect a larger proportion of their work than the poorer students from courses in which the number of *low* grades given is relatively large. Furthermore, it is possible to show that the variations in grade distribution do not represent equal variations in the abilities of the groups of students concerned. We can demonstrate this by comparing the grades attained by a large number of students in certain departments with the grades attained by these *same* students in other departments.

Such a study is summarized in Table III. It exhibits the record in Harvard College of 363 men from twelve classes who later graduated with honor from the Harvard Law and Medical Schools. It gives the exact number of students receiving in a given subject a rank higher than their median rank for all subjects. Thus it appears that English, fine arts, mathematics, classics and modern languages, in the order named, constitute a group in which the grades assigned in this institution are comparatively low. On the other hand, natural sciences, philosophy and history and political sciences, in the order named, make up a group in which the grades assigned are comparatively high. At the two extremes stand English, in which 86 per cent. of the students received lower than their median rank in all subjects, and natural sciences, in which 71 per cent. of the *same* students received higher than their median rank. Furthermore, this table does not represent the extreme variations within departments. The eccentricities of the hardest markers in English and the easiest markers in natural sciences are here offset by the other markers in each department. We must conclude, therefore, that the diverse distribution of grades shown in the figures can not be justified by the unsupported assertion that the students electing certain subjects have far more ability than the students electing other subjects.

The question arises whether it is possible to supplant the personal equation as the chief factor in the awarding of college grades by scientific guidance? The immediate answer to this question depends on whether the distribution of mental traits in groups of individuals follows any regular law—and for the present on nothing else. The ulti-

mate answer to this question will be the discovery of units of measurement in every school subject, and the construction, by scientific methods, of scales that can be applied as the foot-rule is now applied, regardless of time, or place or persons. The best possible ratings of individuals by relative position are only temporary expedients that must some day give way to ratings by means of standard scales. The nearest approach to such a scale, and a perfect illustration of the method, is E. L. Thorndike's "Handwriting," *Teachers College Record,* March, 1910. The Courtis Standard Tests in Arithmetic also furnish a means of comparing the achievement of one school with that of another, and the work of one year with that of another. We are not likely to continue to spend billions of dollars on education and be satisfied with guessing at results. Measurements of results with quantitative precision will be made as soon as people know enough to demand such measurements.

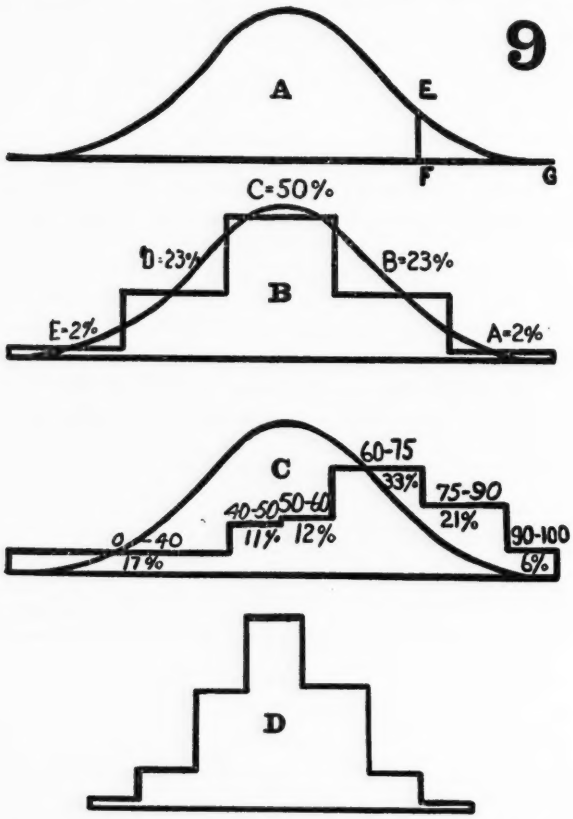
Lacking the necessary units and scales, we may even now ask whether the differences among individuals in mental capacities are explainable by any simple causes and amenable to any single type of description. They are not, if we are to accept the tables and figures just presented as correct records of the abilities of college students. But fortunately we are not dependent on such unscientific data. Psychologists have recently given us many rigorously scientific studies of the distribution of mental traits.

These studies have shown that in any group of individuals representing a single species, the distribution of any trait not greatly influenced by natural selection appears to be that of a chance event. The surface of frequency for that trait approaches that of the probability integral. It is like the cross-section of a pile of sand dumped from a cart. The most convenient way to represent tables of frequencies is by means of diagrams in which distances along a base line represent the different quantities, or units of measurement, and the heights of columns erected upon it represent the frequencies of the several quantities. Fig. 9 presents several illustrations, *D* representing the results of a memory test. By such graphic representations rather that algebraic formulæ, the answer to our question and the evidence for it can be made clear even to one unfamiliar with the mathematical properties of the surface of frequency of a chance event.

Fig. 9, *A,* gives the distribution, or surface of frequency, of the type to which we assume that all distributions of mental traits conform. Fig. *B* is the same type of distribution with a coarser separation into grades. This type is called the normal surface of frequency. It describes, for example, the distribution of accidental errors in scientific observation. Thorndike's numerous measurements show a remarkable uniformity in the distribution of mental traits among individuals. Fig. 9, *D,* showing the memory span for digits in 123 American women stu-

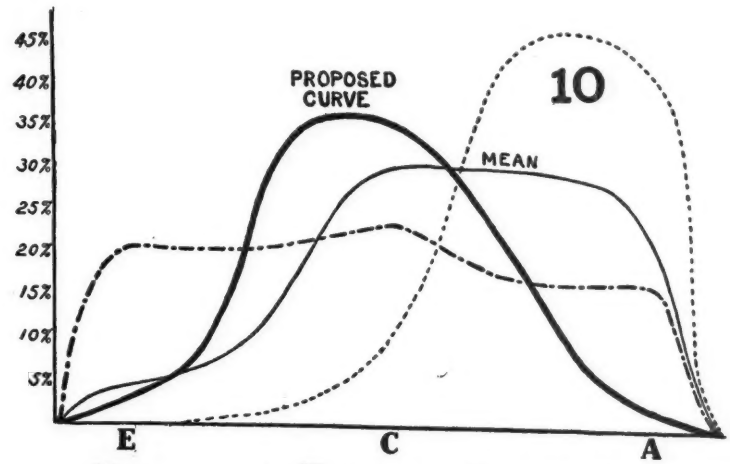
dents, is a good example. In all cases the distribution closely approximates the normal type.

Does the distribution of the complex abilities that determine excellence in college courses approximate this normal type? Theoretically it should, and our theory is supported in a striking way by the distribution of 8,969 grades in twenty-one elementary courses for two years, 1907–08, at Harvard College. The curve in Fig. 11, representing this distribution, is nearly normal. The percentages for the grades A–E are, respectively, 7, 20, 42, 21, 7. Yet there are wide variations among




the instructors in these very courses. In fact not a single instructor came as near to a normal distribution as the sum of all their grades. Now, no one of these markers is as likely to tell the truth as all together. Their several errors correct each other and thus give us, in Fig. 11 (Group 1), a close approximation to the type of curve we should expect to have with an infinite number of cases. In 1909–10, the grades in certain elementary courses in Harvard College (Chemistry 1, Comparative Literature 1, English A, Government 1, History 1, Mathematics F, Philosophy C, Zoology 1) were distributed in the following percentages: A = 5.5, B = 21, C = 44, D = 19.5, E = 9.

The curve for these facts was printed and sent to each instructor with an explanation of its meaning, and a superimposed red curve showing in each case precisely how the instructor's distribution differed from the norm. A table was prepared showing the distribution of grades for all courses having 80 or more students.[3] The range for each grade in per-




*Mean and Extreme Distributions of Grades A-E*

*Total Grades = 2757 Mean Distribution = —— Extreme Distributions = - - -*

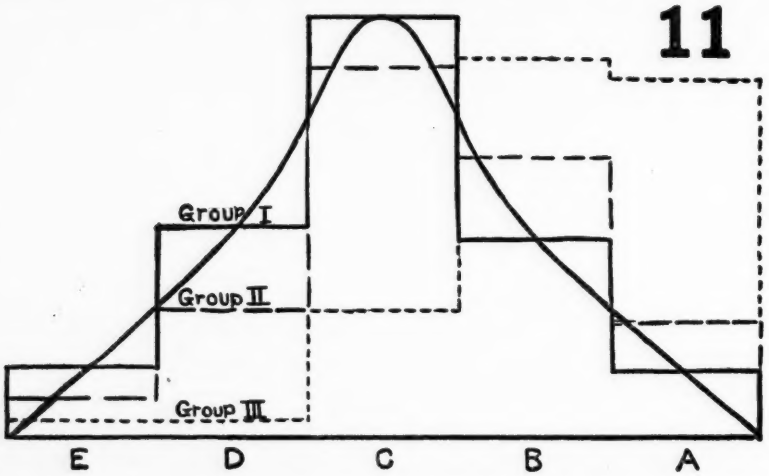
centages was as follows:

| | |
|---|---|
| A | 0.7–20 |
| B | 6–39 |
| C | 27–62 |
| D | 0–31 |
| E | 0–20 |

Accordingly, we have scientific grounds for assuming that a theoretically correct distribution of the grades of college students will approach the normal surface of frequency (Fig. 9, *A* and *B*) unless the group is subject to selection. In that case the curve would be skewed negatively or positively as in Fig. 10.

[3] In Bulletin 368 of the University of Wisconsin, Professor Dearborn attempts to justify the normal distribution of grades "from the fact that it is used in actual practise." Two objections may be made to this contention: first, very few instructors do closely approximate the normal distribution; second, as their practises have no scientific basis, any one of them could only by accident indicate the theoretically correct distribution. If, however, all of Professor Dearborn's curves were represented by one, made from thousands of grades by scores of instructors, it would conform more closely to the general biological law of variation than any of the curves he presents.

As a matter of fact, college students are a selected group.[4] If the surface *A* (Fig. 9) represents the distribution of all elementary school pupils at a given time, then most of those pupils who are to go to college fall in the upper end of that surface. If our colleges took the best students and only the best, if they made a clean cut off the top, then the distribution of their abilities would be represented by a surface closely approximating *EFG* of surface *A*. But for various reasons —including our extremely inaccurate means of attempting to determine fitness for entrance—our colleges do not admit merely those who are best fitted to pursue higher study, that is, the upper end of the




surface. Some pupils find ways into college who occupy stations in the surface not far above the median; or the line of mediocre ability. This is clearly shown in Professor Dearborn's study of the relative standing in scholarship of students in high school and in college. Consequently the lower end of the surface would not be clean-cut as in *EFG*, but rather like the heavy line of Fig. 10. It would, of course, be skewed positively, for there could not possibly be many cases near *G*. Most of them would have to fall in the larger space near *EF*. The curve would be similar to that for incomes. The heavy line in Fig. 10, therefore, though not representing with precision[5] the scientifically correct distri-

[4] Thorndike, E. L., "The Selective Influence of the College," *Educational Review*, 30, 1.

[5] "The curve of probability gives us the only precise meaning of the term 'scientific knowledge.' We have seen that human observations and measurements are never precisely accurate. Generalizations, in like manner, are never precisely true. The formulation of a law of nature can never be made absolutely exact. Scientific knowledge, therefore, is not that absolutely exact and certain knowledge which the popular mind assumes it to be. It is certainty or exactness within a range of error, and to diminish that range is the object of scientific endeavor." Giddings, F. H., "Sociology," Columbia University Press, New York, 1908, p. 24.

bution of college grades, does certainly come nearer the correct frequency curve than the normal curve, or than that representing the present practise of any college or university in the country. In institutions where many sons of rich parents are dragged just above the failure line by tutors, the curve would be skewed even more than in Fig. 10.

As we proceed upward through the years of school and college we should thus expect to find the curve skewed more and more in a positive direction, provided the standards are appropriately higher each year and a new base line is taken for each successive group. Those who accept the principle of normal distribution only for freshman courses in college, or for any single period in the school life of the child, would be at a loss to prove its peculiar fitness for that period.

TABLE III

RECORDS IN HARVARD COLLEGE OF 363 HONOR GRADUATES IN LAW AND MEDICINE

*Number of Students receiving Grades in Certain Departments ABOVE their General Average in all Departments*

| | Fine arts | Natural sciences | Mathematics | Philology | History | Modern languages | English | Classics |
|---|---|---|---|---|---|---|---|---|
| Law graduates | 24 | 68 | 33 | 78 | 86 | 67 | 12 | 41 |
| Medical graduates | 32 | 88 | 36 | 53 | 42 | 50 | 12 | 24 |
| Total | 56 | 156 | 69 | 131 | 128 | 117 | 24 | 66 |

*Number of Students receiving Grades in Certain Departments BELOW their General Average in all Departments*

| | Fine arts | Natural sciences | Mathematics | Philology | History | Modern languages | English | Classics |
|---|---|---|---|---|---|---|---|---|
| Law graduates | 40 | 55 | 33 | 32 | 29 | 84 | 46 | 41 |
| Medical graduates | 45 | 19 | 48 | 33 | 53 | 55 | 109 | 32 |
| Total | 85 | 64 | 81 | 65 | 82 | 139 | 155 | 73 |

*Summary*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Number above | 56 | 156 | 69 | 131 | 128 | 117 | 24 | 66 |
| Subject | Fine arts | Natural sciences | Mathematics | Philology | History | Modern languages | English | Classics |
| Number below | 85 | 64 | 81 | 65 | 82 | 139 | 155 | 73 |

At least two institutions now enforce a distribution of grades on a scientific basis. At the University of Missouri, an A is approximately equal to an A, a B equal to a B, in a defined sense; so that grades may be intelligently and fairly used for administrative purposes. According to the definitions adopted in June, 1908, grades A + B must equal

25 per cent., grade C, 50 per cent., and grades D + E, 25 per cent. of the total number given by each instructor. Under the old system, forty teachers in five years graded their students so that 25 per cent. received A, 35 per cent. received B, and 32 per cent. received C. Moreover, the lack of uniformity among instructors was as great as at Harvard and California. Under the new system the irregularity of the grading was reduced the first year from one fourth to one tenth, or in the ratio of 5 to 2.

The distribution of 24,979 grades in percentages was as follows:

| | Aug., 1908 | Feb., 1909 | June, 1909 | Feb., 1910 | |
|---|---|---|---|---|---|
| B | 23.3 | 20.7 | 21.0 | 21.3 | 26.0 |
| A | 7.7 | 4.6 | 4.6 | 4.7 | |
| C | 41.2 | 47.5 | 48.8 | 49.6 | |
| D | 8.7 | 13.7 | 13.8 | 14.4 | 20.9 |
| E | 15.6 | 8.5 | 8.0 | 6.5 | |
| Delayed | 3.5 | 5.0 | 3.8 | 3.5 | |

Not counting the delayed reports, the distribution of the 11,342 grades for the first year of the new system was, in percentages:

| | | |
|---|---|---|
| A | 4.9 | 26.6 |
| B | 21.7 | |
| C | 50.0 | |
| D | 14.5 | 23.5 |
| E | 9.0 | |

In spite of the adopted definitions, the tendency remains to mark students too high. Every attempt to devise a system of marking whereby extraordinary achievement can be awarded the distinction it deserves has failed because of the democratic tendency in all institutions to place so large a proportion of students in the "distinguished" group. At Dartmouth College, a professor once announced to a large class, "Gentlemen, I must warn you that the committee on instruction has requested me to make my examinations harder, but, gentlemen, I am pleased to say that I shall continue to mark the papers." A century ago a Virginia academy attempted to have its students graded in six divisions,—*bonus, melior, optimus, and malus, pejor, pessimus.* But history records that "the continual tendency was to mark inferior students too high. Thus it came to pass that not half the bad scholars got *malus,* the worst almost never fell below it, and *bonus,* though a mark of approbation, came to be considered as a disgrace, while *optimus,* which ought to have been reserved for scholars of the highest merit, was commonly bestowed on all who rose above mediocrity." As the president of this old institution remarked, "a temporizing professor who loves popularity, and desires, like the old man in the fable, to please everybody, is sure to be guilty of this fault, and like many a politician, to sacrifice permanent good for temporary favor." This is

still the tendency everywhere, in spite of the manifest absurdity of declaring a large proportion of students distinguished.

On the other hand, nearly every institution has instructors who occasionally refuse pass marks to large proportions of their students. It was when a professor in Missouri "flunked" his entire class, and the boards overruled him by passing the entire class, that some of the faculty urged the adoption of a scientific system of grading. The students at another college put more sense than lyrical charm into the following lines:

There was a professor named Bray
Who forgot the reflection on Bray,
When in two of his classes
He gave but few passes,
And frightened good students away.

If an instructor refuses to pass some of the median half of the surface of distribution, it must mean, as a rule, that his methods of instruction or discipline are faulty, or that an unwarranted proportion of students have been admitted to a course they are unprepared to take. In either case, the fault is not with the students, but with the administration of the college.

The distribution of grades by the various departments at the University of Missouri in 1909, under the new rules, showed a range in percentage of A's from twenty in the history of art to zero in political science. The narrow limits of 2 to 7 per cent. included seventy-two per cent. of the departments. Thirteen departments gave the median percentage of A's, which was 4. The entire distribution of grades by departments was published and sent to the instructors, together with a table locating the responsibility for the failure to hold to the adopted definition of grades. The table gave the name of each instructor whose percentage of A–B grades differed from 25 by more than 2, and the name of each instructor whose percentage of D–E grades differed from 25 by more than 4. The table would have been an invaluable guide to students who were seeking the easiest way to get high grades. It was in fact a table of chances.

As a result of this wholesome publicity, the instructors in 1910 showed an even closer approximation to the adopted scheme of distribution. This means that we come nearer to knowing what a grade stands for at the University of Missouri than at any other institution in the country.

Replies from 58 members of the faculty of the University of Missouri in 1910 show that 51 approve of the general principle of standardizing grades and 4 do not approve; only 1 reports that he does not aim to have his grades conform to the system in the long average; 21 tend in grading large, elementary classes to give low marks and offset them by higher marks given to advanced classes, 20 do not; 15 think that

the effect, before the semester is over, is to discourage the efforts of some students appreciably, 23 do not; 26 believe that the effect of the system has been good, 7 regard it as bad, and 23 as inappreciable.

TABLE IV

UNIVERSITY OF MISSOURI

*Distribution of Grades, 1910*

| Subjects of Study | % A | % B | % C | % D | % E | % Del. | Total |
|---|---|---|---|---|---|---|---|
| Class. Arch. and History of Art | 15 | 25 | 39 | 9 | 4 | 8 | 297 |
| Botany | 9 | 19 | 44 | 16 | 10 | 2 | 557 |
| Physical Education | 8 | 17 | 50 | 10 | 15 | — | 649 |
| Latin | 7 | 25 | 45 | 18 | 5 | — | 323 |
| Germanic Languages | 7 | 23 | 45 | 13 | 9 | 3 | 1006 |
| Animal Husbandry | 7 | 22 | 51 | 14 | 4 | 2 | 594 |
| Economics | 7 | 15 | 43 | 23 | 11 | 1 | 369 |
| Agronomy | 6 | 26 | 57 | 4 | 6 | 1 | 321 |
| Horticulture | 6 | 23 | 47 | 13 | 8 | 3 | 495 |
| Music | 6 | 20 | 58 | 4 | 11 | 1 | 280 |
| Law | 5 | 24 | 52 | 10 | 2 | 7 | 3984 |
| Experimental Psychology | 5 | 20 | 53 | 14 | 7 | 1 | 497 |
| Mathematics | 5 | 20 | 49 | 12 | 11 | 3 | 962 |
| Philosophy | 5 | 14 | 45 | 20 | 12 | 4 | 336 |
| Veterinary Science | 4 | 27 | 59 | 7 | 2 | 1 | 292 |
| History | 4 | 26 | 49 | 13 | 5 | 3 | 1023 |
| Sociology | 4 | 23 | 51 | 16 | 5 | 1 | 594 |
| Education | 4 | 22 | 50 | 16 | 7 | 1 | 751 |
| Journalism | 4 | 21 | 59 | 12 | 3 | 2 | 342 |
| Political Science | 4 | 21 | 44 | 22 | 3 | 6 | 280 |
| Philosophy of Education | 4 | 20 | 53 | 19 | 3 | 1 | 365 |
| Home Economics | 4 | 20 | 53 | 15 | 2 | 6 | 220 |
| Physics | 4 | 20 | 43 | 19 | 8 | 6 | 1030 |
| Electrical Engineering | 3 | 22 | 49 | 18 | 4 | 4 | 491 |
| Mech. Draw. and Hydr. Engin. | 3 | 22 | 49 | 12 | 8 | 6 | 726 |
| Mechanical Engineering | 3 | 21 | 53 | 16 | 6 | 1 | 642 |
| Romance Languages | 3 | 21 | 49 | 14 | 10 | 3 | 468 |
| Shopwork | 3 | 20 | 59 | 12 | 3 | 3 | 376 |
| Theory and Practise of Art | 3 | 19 | 48 | 15 | 9 | 6 | 289 |
| English | 3 | 18 | 50 | 18 | 8 | 3 | 1583 |
| Chemistry | 3 | 16 | 46 | 20 | 12 | 3 | 1379 |
| Elocution | 2 | 25 | 50 | 21 | 2 | — | 232 |
| Civil Engineering | 2 | 21 | 52 | 18 | 5 | 2 | 836 |
| Zoology | 2 | 19 | 49 | 20 | 8 | 2 | 391 |
| Geology and Mineralogy | 2 | 17 | 57 | 16 | 6 | 2 | 344 |
| Military Education | 2 | 16 | 52 | 6 | — | 24 | 293 |

Discarding the arbitrary divisions employed wherever undefined symbols and numbers are used, we may divide the area of the normal surface of frequency as it is always divided for other scientific purposes. We may mark off a middle area equal to the sum of the two areas left at the sides. Half the students of any group will be represented by this middle area. We may designate this group by the symbol C, or K, or 75, or 13, or 289, or we may name it after the chairman of the school board. Much will be gained when we rid ourselves of the notion that the letters and numbers we now use so widely necessarily have any particular meaning. What we call this group does not matter: the significant thing is that it stands for an ability above and below which half

the cases lie. It means that a student taken at random from a class of one hundred has one chance in four of falling above the middle group. It means that if we represent the ability of this group by C, we know precisely what an instructor means when he gives a student that grade. He means that the ability of the student in his course is greater than that of one fourth of the course and less than that of another fourth of the course. This median group ought to be the largest, for it is where most human beings fall, as shown by the height of the probability curve.

We can not indicate real distinction, however, unless we subdivide the upper quartile. We can do this arbitrarily or we can turn to a table of values of the normal probability integral.[6] Here the extreme ability is called 3. The point of the vertical line which separates the median group from the inferior group is .68. Half way between 3 and .68 is 1.84. Accepting this as the division point for the upper and the lower quartile, we find at the upper end of the surface of distribution three per cent. of the whole, and at the lower end three per cent. If we indicate the five sections, from the upper end to the lower, by the symbols A, B, C, D, E, we have the following distribution of grades:

| | Per Cent. |
|---|---|
| A | 3 |
| B | 22 |
| C | 50 |
| D | 22 |
| E | 3 |

If, on the other hand, we assume that the distribution of abilities of college students is not normal, but skewed, the following percentages for each grade would more nearly represent the facts:

| | Per Cent. | |
|---|---|---|
| A | 2 | 20 |
| B | 18 | |
| C | 50 | |
| D | 24 | 30 |
| E | 6 | |

As variation in the abilities of those who elect a given course is sure to occur from year to year, some would prefer an elastic definition of the grades; for example:

| | Per Cent. |
|---|---|
| A | 0– 6 |
| B | 15–21 |
| C | 45–55 |
| D | 20–28 |
| E | 0–10 |

[6] A table of values of the normal probability integral is found on page 148 of Thorndike's "Mental and Social Measurements." In *Science*, 712, 243, Max Meyer uses this basis for dividing the probability surface.

Any one of these definitions of the meaning of the five groups would come nearer to telling the truth, be more serviceable for administrative purposes, and convert the vast amount of labor now used in making out grades into more valuable data for the scientific study of education than the present personal distribution of college credits. A defensible definition of grades should be adopted by each faculty and its members should be required to adhere closely to it, in the long run, at least in all courses primarily for undergraduates, until we can supplant the method of grading by relative position by scales made up of equal units.

After the definition of grades is adopted, a table should be sent to each instructor, as often as grades are required at the college office, showing the distribution of grades in each course in the college and emphasizing those that depart far in either direction from the adopted mean. Every instructor should be requested to justify his eccentricities, at least in a series of years. If such publicity does not accomplish sufficient uniformity for administrative purposes, insurgent and careless instructors should be reminded by the appropriate authorities that it is for the interest of all for each to abide by the decision of the faculty.

To rate instructors solely with respect to the proportion of high grades awarded by them, or solely with respect to the quality of students attracted to their courses, is evidently inadequate. An instructor may give more high grades than his associates, because he has more students who deserve distinction. But if this is the case, the administrators of the college curriculum can readily devise a means of measurement which will show at a glance the justification for any *conspicuous* deviation from the normal distribution of grades. All the instructors of any institution may be located on a scale which shall take account not only of the grades awarded, but as well of the quality of the students electing each course.

For example, as part of an investigation conducted at Williams College by a committee in accordance with a resolution of the faculty, Dean Ferry, at the request of the president, devised a plan for measuring the relative quality of the classes in the elective courses of junior and senior years and of the grades given in each. Taking the work of the first two years, where the courses are nearly all prescribed, as a basis for the determination of the scholarship of the students, statistics were carefully worked out for the elective courses of three successive classes. The results of his extensive study are summarized in Table V. Column I. gives each instructor his position with respect to the quality of students in his courses. The larger the proportion of men attracted to his courses from the upper half of the student body in general scholarship, the larger the plus rating of the instructor. For purposes of comparison, Column II. gives each instructor his position with respect to the proportion of high

grades and low grades assigned to him. Thus, for example, instructor number 4 has the high rating of 41 in the quality of his students and the low rating of — 23 in the assignment of grades. Instructor number 26, on the contrary, has the low rating of — 21 in quality of students and the high rating of 52 in grades assigned. In other words, he has a conspicuously large proportion of the students whose general scholarship is low, and to these poor students he awards a conspicuously large proportion of high grades. Many a teacher would be surprised to discover his standing on such a scale, and the college administrator who undertakes to deal with such discrepancies, through discussion with individual members of the faculty, will do well to provide himself with a quantitative presentation of the facts.

TABLE V

A Rating of Elective Classes in Williams College

| | I | II | | I | II |
|---|---|---|---|---|---|
| 1 | 113 | 0 | 16 | 2 | 41 |
| 2 | 113 | 0 | 17 | 1 | 42 |
| 3 | 77 | 27 | 18 | — 1 | 56 |
| 4 | 41 | —23 | 19 | — 2 | 6 |
| 5 | 39 | 23 | 20 | — 4 | —11 |
| 6 | 39 | —21 | 21 | — 5 | 89 |
| 7 | 24 | 3 | 22 | — 7 | 63 |
| 8 | 20 | 49 | 23 | — 8 | 59 |
| 9 | 17 | 50 | 24 | —14 | 40 |
| 10 | 15 | 34 | 25 | —17 | 95 |
| 11 | 13 | 20 | 26 | —21 | 52 |
| 12 | 9 | 41 | 27 | —22 | 89 |
| 13 | 7 | 32 | 28 | —30 | 114 |
| 14 | 6 | 58 | 29 | —33 | 66 |
| 15 | 5 | 63 | 30 | —40 | 73 |

Such regulation will be resented by many college teachers as an infringement on their rights. But academic freedom that allows each member of a faculty to do as he pleases in matters that reach far beyond the interests of his own department is intolerable license. As President Eliot has said:

> A faculty can properly criticize the results of any professor's, or other instructor's, work as they appear in certain easily visible ways. Among such visible evidences are . . . the resort of obviously incompetent or uninterested students to his courses; examination papers of a trivial or pedantic sort; uniform high grades or uniform low grades returned by the professor; an extraordinary number of distinctions earned in his courses; or an extraordinary number of rejections and failures. These are legitimate subjects of inquiry by a faculty committee or by faculty officials, and can be dealt with by a faculty without impairing just academic freedom. The knowledge that this power of revision resides in a faculty is a valuable control over individual eccentricities.

It is sometimes said that "there are usually some courses in a university which, from year to year, secure only an inferior grade of pupils, and other lines of work which, for various reasons, secure a dis-

proportionate number of superior students. Classical students in the high school and university, and students in the advanced courses in mathematics, are often examples of such selected groups of students. The above principle would not be equitable in these cases." In answer to this argument, it should be noted, first, that it is, in large part, the very grading to which objection is raised that has caused the resort of poor students to certain courses; and, second, if the better men do resort in larger proportions to certain courses, that fact can be readily shown by statistics. It is one of the many educational questions on which speculation and opinion are quite out of place.

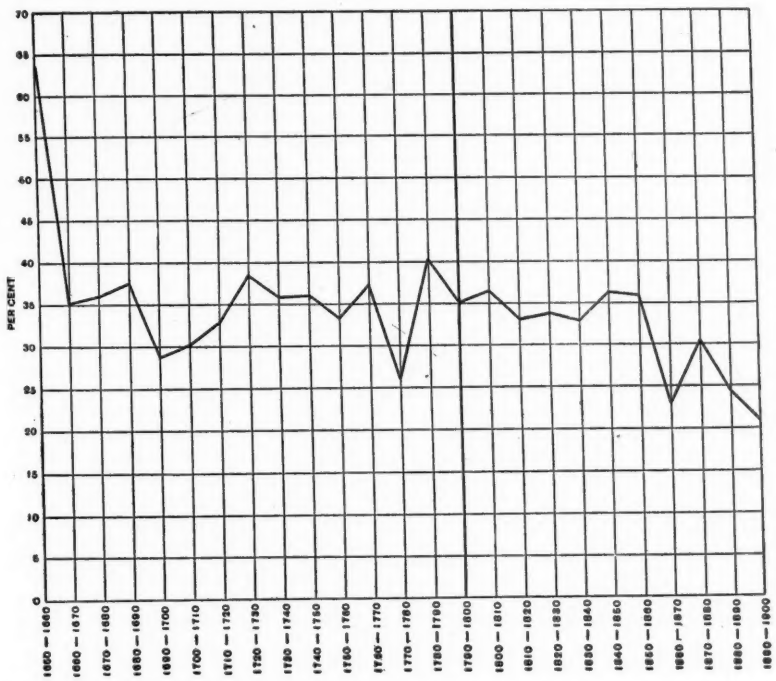
Without a scientific administration of college credits, the other safeguards of the elective system are insufficient. There will always be students who are more interested in getting through their courses than in getting profit from them. The poorer students seek the courses which give the larger proportions of high grades. Earnest but needy students, too, are under great temptation to elect courses with a view to winning money scholarships, as long as scholarships are awarded on the false assumption than an A is equal to an A. To all students who are prompted by unworthy motives in the election of studies, Figs. 1 to 11 are charts pointing the easiest courses to a degree. And students in all colleges are guided by such charts, more or less accurately plotted. It is futile for the authorities to try to suppress such information and protect their instructors from the notoriety they deserve. Nor is the elective system to blame for the presence of snap courses and the relative ease with which high grades are secured from certain instructors. Nor is the credit-for-quality plan to be condemned because it accentuates the evils of our marking devices. The best way to safeguard the elective system and the credit-for-quality plan against the evils here set forth is to enforce a scientific distribution of college credits.

# THE PROGRESS OF SCIENCE

## *THE POPULATION OF THE UNITED STATES IN 1910*

PRELIMINARY announcements have been made of the population of the states and of some of the cities as determined by the thirteenth census. The population of continental United States is 91,972,267, as compared with 75,994,575 in 1900, an increase of 21 per cent. This is the smallest rate of increase hitherto recorded, but is practically the same as for the preceding decade. The accompanying chart shows the percentages of increase, those prior to the first census of 1790 being somewhat rough estimates. Apart from drops at the time of the war of revolution and the civil war the percentage remained very constant for two centuries, but in spite of the large immigration it has dropped in the past fifty years from 35 to 21.

It is unsafe to make any prediction from such figures but it is clear that the increase in population has been maintained by immigration and by a falling death rate, and it is doubtful whether these factors will continue to make up for the declining birth rate. In 1820 there were 489 children under 16 years old among each thousand of the white population—that is, about half were children. In 1900 the number of children had fallen to 356 and in New England to 291. Or, to put the matter in another form, there were in



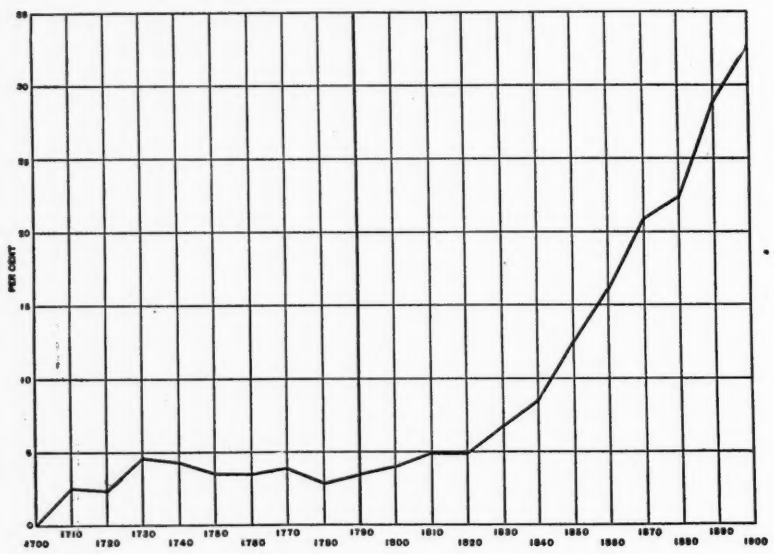

PERCENTAGE OF INCREASE IN THE POPULATION OF THE UNITED STATES BY DECADES FROM 1650 TO 1900.

1790 nearly four children under 16 for each three adults, in 1840 an equal number of children and adults, in 1900 more than three adults for each two children. If the proportion of children in 1790 had been maintained there would be at present in this country about twenty-five million children who are unborn.

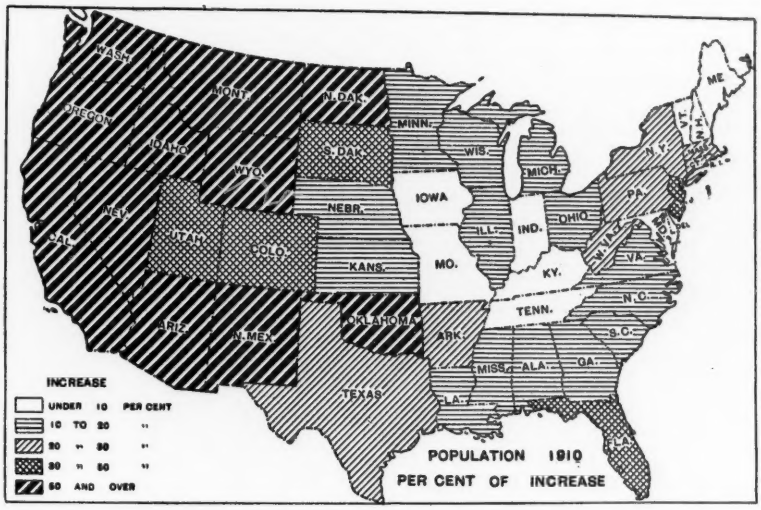
Next in significance to the declining birth rate and the lack of children and related to them is the decreasing rural population and the increasing urban population. This change is shown in the curve; the percentage of the population living in cities and towns with a population of over 8,000 has increased from 3.3 per cent. in 1890 to 32.9 per cent. in 1900. In 1790 there were six places having a population as large as 8,000; in 1900 there were 545 such places.

The increase in population of the several states from 1900 to 1910 is shown on the map. The percentage of increase is clearly greatest in the west, the population having more than doubled in Washington, Oklahoma and Idaho, and having increased more than 60 per cent. in California and Oregon. In the east Massachusetts and Pennsylvania have about maintained the average increase, while New York has exceeded it with a gain of 25.4 per cent. Although the details have not been announced it is clear that the states having relatively the largest rural population have increased most slowly. The three rural New England states show a gain of about five per cent. But the most striking fact is the stationary condition of the great agricultural states of the middle west. Iowa has actually a smaller population in 1910 than in 1900; the increase in Indiana is 7.3 per cent., in Missouri 6, in Kentucky 6.6, and these small increases are due to the cities.

The relative increase in the population of the country during the last decade was smaller than ever before and this increase was due mainly to the settling of the west and to the foreign immigration to eastern cities. The depopulation of the country districts and the lack of children are ominous for the future.




PERCENTAGE OF THE TOTAL POPULATION OF THE UNITED STATES IN CITIES OF 8,000 AND OVER.



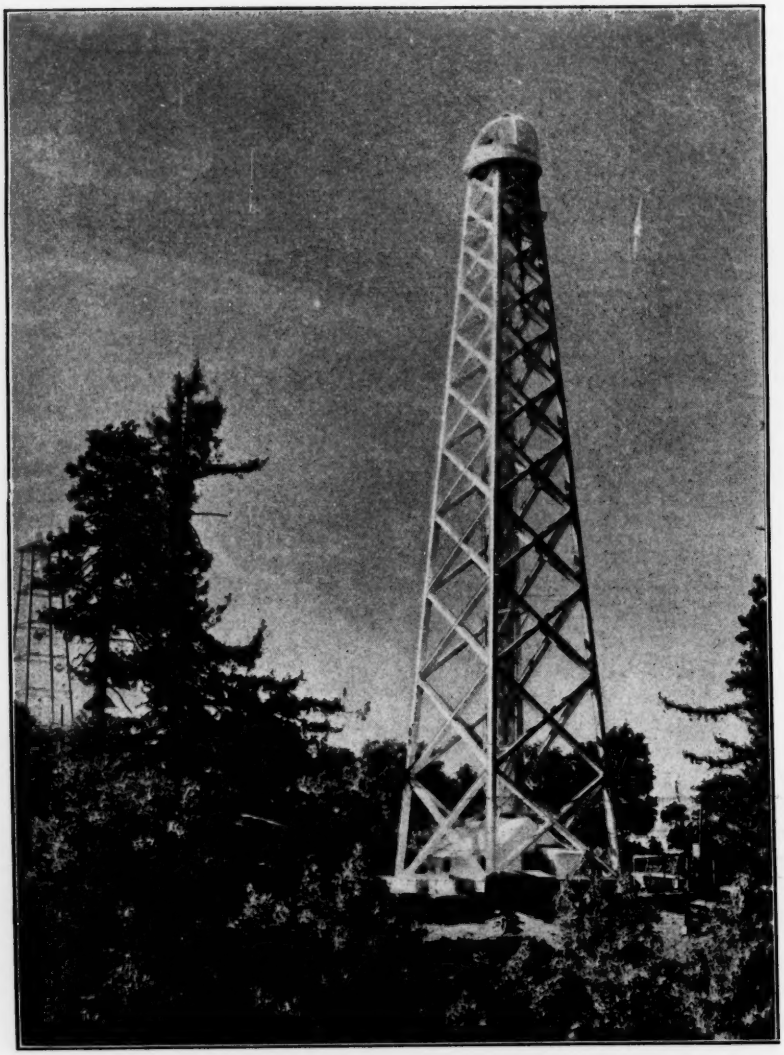

## *THE RESEARCH WORK OF THE CARNEGIE INSTITUTION*

MR. CARNEGIE'S recent gift of $10,000,000 in bonds of the U. S. Steel Corporation to the institution which he established in Washington nine years ago gives it an endowment of $22,000,000 in securities bearing 5 per cent. interest and worth at least $25,000,000. The endowment of Stanford University is about the same, and Mr. Rockefeller's endowment of the University of Chicago is about $10,000,000 greater. Each of these institutions through the gift of a single man has resources larger than any university has had until very recently, and aproximately equal to the present endowments of Harvard and Columbia. If this country does not assume the leadership in scientific research and productive scholarship, it will not be through lack of endowment.

The work of the Carnegie Institution is each year reported with clearness and fullness in the year-book. The president gives an account of the financial operations and a summary of the investigations accomplished and in progress and the heads of departments and the recipients of grants describe their work. Last year the sum of about $440,000 was appropriated for the ten research departments, about $90,000 for minor grants and research associates, about $100,000 for publications and about $45,000 for administration. Among the research departments astronomy fares the best with an appropriation of over $150,000, and geophysics and terrestrial magnetism next, with over $125,000.

The solar observatory on Mt. Wilson reports the results of nineteen researches concerned largely with sunspots and the sun's spectrum, but extending also to stellar spectroscopy and photography. The tower telescope, shown in the accompanying illustration, is now complete except the spectroscopic attachments. A well in the rock below 75 feet deep forms part of the tube of the instrument. The meeting of the Solar Union at the observatory has been described in this journal. The department of meridian astronomy has conducted observations in Argentina and compilations at the Dudley Observatory.

The geophysical laboratory has concerned itself with the study of rocks under experimental conditions more especially with reference to temperature and pressure. The non-magnetic ship of the department of terrestrial magnet-

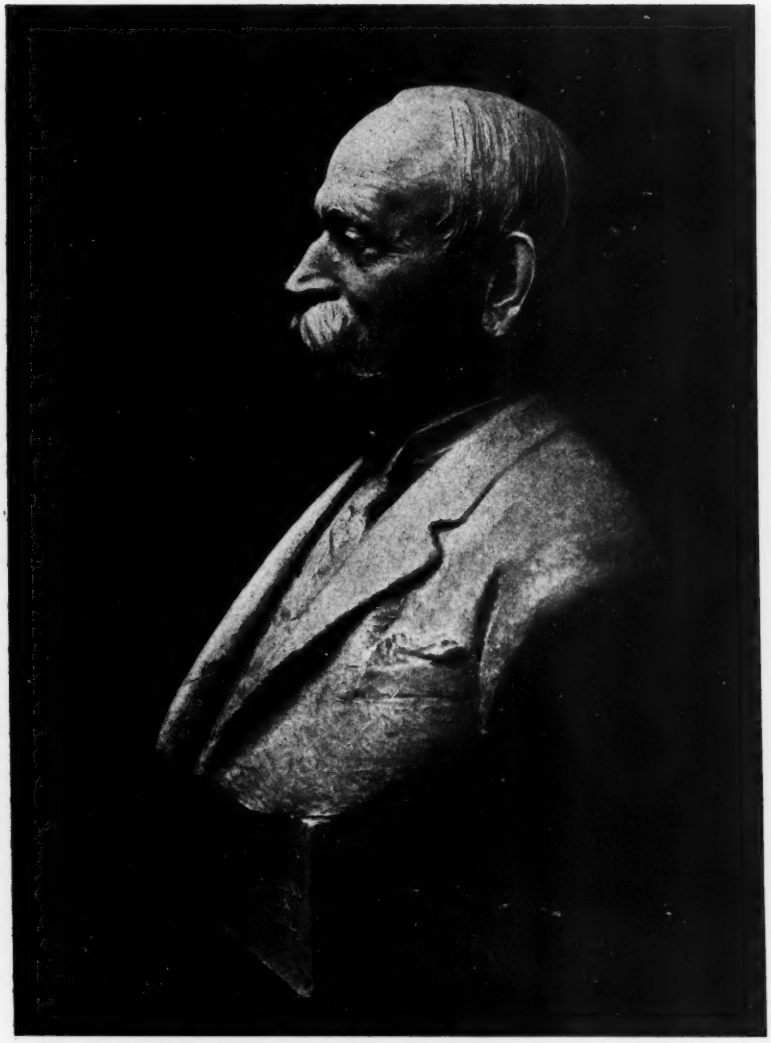


TOWER TELESCOPE OF THE MOUNT WILSON OBSERVATORY.

ism, having been tested on the Atlantic, is now on a cruise around the globe which will cover about 65,000 miles.

The institution is only undertaking minor work directly in physics and chemistry, though these fundamental sciences are concerned with the research of all the departments, and in the case of the nutrition laboratory, physiological chemistry may be regarded as the field of investigation.

There are three departments devoted to the biological sciences. The work in botany has its headquarters at Tucson, Ariz., where the desert conditions are desirable for experimental research in certain directions. In equally favorable situation for its special work is the marine biological station on one of the Tortugas off the coast of Florida. The station for experimental evolution at Cold Spring Harbor, Long Island, has



BRONZE BUST OF DR. C. F. CHANDLER.

**Presented to him by the chemists of America on the occasion of his retirement from the active duties of the Mitchill chair of chemistry in Columbia University.**

AN OLD CAMBRIDGE LANDMARK.

acquired additional land, including an island in the sound which can be used for the experimental isolation of plants and animals.

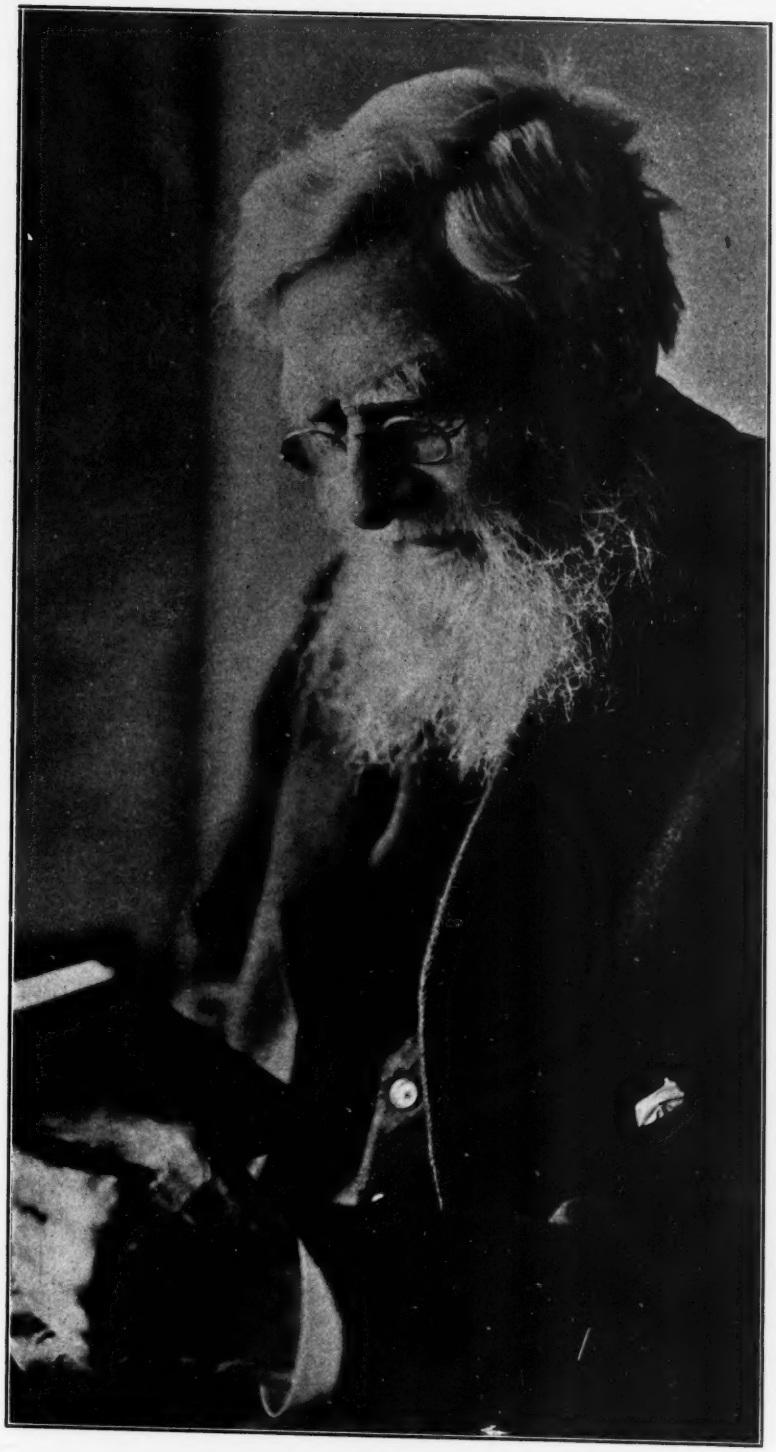
While the work of the Carnegie Institution is mainly in the natural and exact sciences there are departments of economics and sociology and of historical research, certain classics of international law are being republished and appropriations are made to the American schools of classical studies at Athens and Rome.

### *THE HOUSE OF ASA GRAY*

*The Harvard Graduate's Magazine* gives a picture, here reproduced, of the house in the Botanic Garden of the university with some account of the history of this old landmark by Professor Robinson. Such a frame dwelling house is almost as characteristic of Cambridge conditions as the courts and quads of the colleges of English universities, for it has scarcely been respectable for a Harvard professor to live in a house of brick or stone. This house was built in 1810 for William Dandridge Peck, the first professor of natural history at Harvard and the organizer of the Botanic Garden. After Peck's death in 1822, it was apparently used as a boarding house and in it lived Thomas Mitchell, lecturer on natural history, an eccentric bachelor of English birth. Asa Gray was appointed professor of natural history in 1842, and lived in this house from his marriage in 1848 to his death in 1888, and Mrs. Gray continued to live there until her death in 1909. In this wooden house were kept the herbarium and library of Asa Gray until 1864, when the university provided a building, fireproof according to the standards of these days. To obtain space for the enlargement of the herbarium building and to avoid the danger from fire, the old house has now been sold and is being removed from the botanic garden, but will be restored without considerable changes in its form.

### *SCIENTIFIC ITEMS*

WE record with regret the deaths of Dr. Edward Hitchcock, for fifty years



DR. ALFRED RUSSEL WALLACE,
the English naturalist, in his eighty-ninth year.

professor of hygiene and physical education at Amherst College; of Professor Frank J. Phillips, head of the department of forestry in the University of Nebraska; of Dr. Walter Remsen Brinckerhoff, assistant professor of pathology in the Harvard Medical School; of Dr. Aloysius Oliver Joseph Kelly, assistant professor of medicine in the University of Pennsylvania, and of Professor J. H. van't Hoff, eminent for his contributions to physical chemistry.

THE congress has passed a bill to retire Commander Robert E. Peary, with the rank and pay of a rear-admiral and to extend to him the thanks of congress.—Sir William H. White has been awarded the John Fritz medal for 1911, for "notable achievements in naval architecture," by the national societies of civil, mining, mechanical and electrical engineering. The first award was made in 1905 to Lord Kelvin, and subsequently to Alexander Graham Bell, Thomas A. Edison, George Westinghouse, Charles Porter and Alfred Noble.—Various honors have been conferred on Dr. Paul Ehrlich, director of the Institute for Experimental Therapeutics at Frankfort, whose work was the subject of an article in the last issue of the *Monthly*. The Emperor of Russia has conferred on him the Order of St. Anne First Class, with a badge set in diamonds. The King of Spain has bestowed on him the Grand Cross of the Order of Alfonso XII. The German Emperor has nominated him a member of the senate of the recently founded Kaiser Wilhelm Society for the Advancement of Science; on this body he is the only representative of medicine. The St. Petersburg Institute of Experimental Therapeutics has elected him an honorary member. The municipal authorities of Buenos Aires have given Professor Ehrlich's name to a street in the suburb of San Fernando.

M. AUGUSTE LOUTREFIL has bequeathed $700,000 to the Paris Academy of Sciences, $500,000 to the University of Paris and $20,000 to the Pasteur Institute.—Herr Leopold Koppel, a Berlin banker, has given $175,000 for the erection of a research institute for physical chemistry in Berlin and will make a further gift of $87,500 extended over the next ten years for maintenance.—It is announced that Professor Hans Meyer has presented 150,000 Marks to the University of Leipzig for the laboratory of experimental psychology established by Professor Wilhelm Wundt.